NATIONAL BUREAU OF STANDARDS REPORT

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EARTH TEMPERATURES BENEATH FIVE DIFFERENT SURFACES

Final Report

OCD Work Order DAH20-68-W-0106
Work Unit 1211A

NBS

U.S. DEPARTMENT OF COMMERCE
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Work Unit 1211A

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Report to
Office of Civil Defense
Office of the Secretary of the Army
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U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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Summary

This is the final report covering the experimental effort of measuring, processing and analyzing earth temperature data beneath five different surfaces collected during March, 1969 through February, 1970. Since the instrumentation and data processing phases of the endeavor have been described in the previous NBS Report 10223 entitled "Automated Earth Temperature Station", only the analysis of the data is given in this report. Annual and typical daily plots of earth temperature under black, white, bare, short grass, and long grass surfaces are presented together with the surface weather conditions and soil moisture content.

The earth temperature under the asphalt paved surface was found to be tremendously affected by the solar radiation during the summer, and average temperatures under this surface were considerably higher than under the grass covered (undisturbed) surface; 8 °F higher at the surface, 6 °F at the 10 ft depth, 5 °F at the 20 ft depth and less than 1 °F at the 30 ft depth. The difference in monthly average temperature is of course much higher than the annual average. Annual maximum monthly average temperature at the 10 ft depth is 68 °F under paved surface in comparison with 61 °F under the natural surface. Daily maximum surface temperature of the paved surface reached 140 °F whereas the natural surface temperature seldom exceeded 100 °F. An interesting observation was that the natural surface temperature was almost 10 °F lower than the ambient air temperature early in a cloudless summer morning whereas the paved black surface temperature remained higher than the air temperature in the same period.

It is important to note that the temperature under the paved surface could be decreased considerably by applying regular highway white paint. Even during the second year when the painted surface became quite stained, the temperature under it was not greatly different from that of the bare surface. Its surface temperature never exceeded 105 °F.

A least squares technique was applied to the earth temperature data resulting in the average thermal diffusivity of the soil to be approximately 0.02 ft^2/hr, which is reasonable for the silty sand of 13% moisture content and dry density of 115 cu. ft/lb.

Despite the relatively large amount of rain during the test period and even during the prolonged snow coverage, the soil moisture content did not change appreciably.

This report shows that the average ground temperature to 10 ft depth is considerably affected by the surface condition, particularly under the black paved surface. For the purpose of the underground installation, it is recommended that the design earth temperature be raised at least 15 °F above the current design values for the summer condition. The average winter design temperature, however, need not be adjusted for the paved surface.

Earth Temperatures Beneath Five Different Surfaces

Background

The subject of earth temperature has been the concern and interest of the author for many years, and especially recently, since his involvement with the heat transfer analyses of underground fallout shelters. When the fallout shelter investigations were under way, there was no rational data for predicting the heat dissipation of the underground structures. The majority of earth temperature data available in those days were from agricultural research centers for plant ecology. In order to improve the existing design data for the underground installation, the author pointed out the need of systematic studies for earth temperature in relation to the climatic factors, surface covers, solar radiations and soil conditions. Fortunately, the enthusiasm and concern of the author was as strongly shared by Mr. F. D. Allen of the Office of Civil Defense, and under his recommendation, OCD research funds were allotted to the National Bureau of Standards to conduct hourly gathering of earth temperatures under five different ground surface conditions for a period of two years. The earth surfaces chosen to be studied were paved surface, paved and painted white surface, bare surface, grass covered surface, and shaded surface. Due to the difficulty of obtaining a shading device suitable for 50' x 50' patch, the plan to test the artificially shaded surface was discarded and a surface with long grass was used in its place.

Initial planning of the study started as early as 1965 and chronological sequence of major events can be listed as follows:

December, 1966 - First well was bored and soil core samples were taken

July, 1967 - Patch No. 1 and 2 were paved with 4-inch thick asphalt

December, 1967 - The second well was bored and the second set of soil samples was taken for detailed analyses

January 22, 1968 - The automated data acquisition system was delivered

March, 1968 - The instrument bunker was completed

April 10, 1968 - All the underground transducers were installed

April 19, 1968 - The weather instrument platform was built

May 10, 1968 - The data acquisition system was moved into the instrument bunker

June 3, 1968 - Patch No. 1 and 2 were repaved with an extra one-inch thick asphalt coating making their total paving thickness 5 inches

June, 1968 - Heavy rain during this month caused the minor floods in the bunker but did not cause any extensive damage until

June 17, 1968 - The flooding was so severe that it damaged most of the instruments

July 15, 1968 - The data logger was back in operation but the replacement for the Modems*/ in the data transmission could not be obtained for a long time because of the shortage in supply. It was decided that the data would be collected manually at least once a day until the Modem replacement was found

July 31, 1968 - Patch No. 2 was painted white

August 21, 1968 - An air conditioner was installed in the instrument bunker to prevent the excess temperature rise during the day

September and October, 1968 - Frequent system outages occurred mostly coincident with thunderstorms

February, 1969 - Epply solar radiometer for the diffuse sky radiation was blown off the weather platform

February 26, 1969 - All the instruments were finally repaired

March 1, 1969 - A full scale data acquisition was started

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*/ An interface device between the telephone line and the data logger.

During March 1, 1969 through the end of February 29, 1970, the data were collected every hour but there were many outages, dates of which are listed as follows:

1969

March 18, 26

April 8, 21, 22

May 8, 22

June 3, 4, 9, 19, 23

July 3, 9, 14, 18, 20

August 4, 5, 7, 19, 21

September 1, 11 through 15, 26, 29

October 1 through 13 - Power outage in the vicinity of the shelter

November - The shelter system was operating but was very erratic

December 1

1970

January - none

February 19

As seen from this list of the system outages, there were considerable difficulties in maintaining the continuous operation of the data acquisition system. The major trouble was that whenever the system was down, there was no immediate service capability available. The system was built by a company that later became practically defunct. A special consultant had to be hired for the basic minimum service.

The difficulties encountered were not limited to the data acquisition hardware but was also extended to the data processing equipment connected with the paper punch tapes. These tapes had to be converted to magnetic tapes to be analyzed by the NBS computer. This tape conversion turned out to be a very erratic process. Much unnecessary effort and computer time was needed to overcome various barriers between the paper tape and the NBS computer.

In spite of these hardships, it was possible to assemble relatively complete hourly data of earth temperatures beneath five different surfaces, coincident with detailed surface weather observation and soil data.

Figure Captions

Table Titles

1. Introduction

Presented in this report are the results of the earth temperature study conducted at a site on the National Bureau of Standards grounds. This research program has been sponsored by the Office of Civil Defense in order to improve the existing thermal design information for various underground installations. Except for the work of Black[1/], earth temperature has not been treated in the past, particularly in relation to the soil properties, solar radiation and surface weather conditions.

The general scope of this investigation, descriptions for site characteristics, and experimental apparatus were all described in the previous NBS Report 10223 entitled "Automated Earth Temperature Station[2/]. Five patches of 50' x 50' area were designated on the National Bureau of Standards grounds. The surface of these patches were prepared to represent five different conditions:

1. Asphalt (5" thick) covered
2. Asphalt (5" thick) covered but painted white with regular highway paint
3. Bare soil surface
4. Grass covered but kept to 4" high throughout the year
5. Grass covered and left unmowed.

Figure 1 shows the location of these patches. At the geometric centers of each patch thermal probes were installed, encased in a 1" polyethylene tube, detail of which is shown in Figure 2.

A special-purpose digital data acquisition, communication and processing system was set up in the Environmental Engineering Section of the National Bureau of Standards to analyze approximately 100 channels of hourly signals from the multitude of thermocouples, heat flow meters and other transducers for a period of one year--from March 1, 1969 through February 28, 1970. The description of these 100 data channels are given in Table 1.

Because of the automated instrumentation system, it was possible to store the hourly values of earth temperatures and other related data for a period of 8760 hours with relatively less effort than otherwise required. There were, however, several serious instrumentation failures which resulted in occasional and prolonged interruptions. The data were first stored in rolls of punched paper tapes and these punched tapes were in turn converted into magnetic tapes in a form acceptable to the NBS computer, UNIVAC 1108.

A computer program called SOIL was developed to read the magnetic tapes and to convert the observed data, which were in mV form, into appropriate engineering units as shown in Table II. The engineering data thus obtained were again stored in final magnetic tapes in binary form for the purpose of obtaining annual plots.

Figures P-1 through P-73 show the annual plots of the final data and these plots essentially represent the entire effort of this project. Discussed in the following section are the observations made from these plots.

2. Soil Condition in the Test Site

Before the earth temperature data obtained during this study is discussed, it is pertinent to describe the ground conditions of the site.

As shown in the Appendix of Report 10223, the soil of the earth temperature site was silty sand with a trace of mica. Its dry density was approximately 115 lb/cu. ft and the moisture content 13%. The ground water was checked at the two 30 ft deep walls in the test site. The wells were found to be dry throughout the test period. The change of the soil moisture content during the test period was also monitored by soil moisture gauges, details of which were given in Report 10223. Very small soil moisture changes were detected throughout the test period as shown in Figure 3. There also appeared to be no correlation between the soil moisture change and the monthly rainfall pattern as indicated in Figure 4.

Worth mentioning is the fact that there was snow on the ground for the major part of January except on the black paved surface. Even this prolonged snow coverage did not significantly alter the readings of the soil moisture gauges buried at about 4" depth[*/]. Relatively constant ground surface temperatures during January as shown in Figures P-13, 25, 37 and 49 are evidence of extensive snow covering during that month.

[*/] It is possible that the moisture gauges were not functioning properly. Report 10223 describes the soil moisture measuring system.

3. Annual Cycles

Figures P-1 through P-59 indicate seasonal profiles (30 day average) superimposed on the daily fluctuations. It is shown that the diurnal temperature fluctuation very quickly decays as the depth is increased beyond one foot. The occasional and abrupt spikes appearing on the data of more than one foot depth are due to instrumentation noise and should be considered spurious.

The seasonal temperature fluctuations under five different surface conditions are plotted in separate sheets as shown in Figures 5 through 9. Generally, as expected, the earth temperature under the black surface is the highest and that under the long grass covered surface the lowest. The maximum temperature differences between these two extreme conditions are approximately 20 °F near the ground surface (to the depth of 4 ft), 13 °F at the 10 ft level, 7 °F at the 20 ft level and 4 °F at the 30 ft level. These maximum temperature differences, however, occur in different months depending upon the depth; the maximum difference was during the summer near the surface and during the winter at the 30 ft depth. Shown in Tables ST-1 through 5 are the monthly average of observed earth temperatures and those calculated by a special least squares technique[3, 4]. This least squares technique was designed to fit the earth temperatures to the following equation

$$t = A_o + e^{-\sqrt{\frac{2\omega}{\alpha}} Z} \left[A_1 \cos \left(\omega\theta - \sqrt{\frac{2\omega}{\alpha}} Z\right) + B_1 \sin \left(\omega\theta - \sqrt{\frac{2\omega}{\alpha}} Z\right)\right] \tag{1}$$

where t = earth temperature at time θ and depth Z

$\omega = \frac{2\pi}{T}$ radians/hour

T = period of annual cycle, (= 8760 hours)

α = thermal diffusivity of earth, ft^2/hr

Z = depth, ft

A_o, A_1, B_1 = least squares constants

θ = time, hour starting from midnight of January 1

e = exponential function

This least squares technique, used to find the values of α_1, A_o, A_1 and B_1 to best fit the observed temperature is described in reference [2].

Reference [2] shows that the monthly average earth temperature is relatively insensitive to the value of the thermal diffusivity α, and the majority of the U. S. earth temperature data can be fitted to equation (1) with α approximately 0.02 $\sim$ 0.025 ft^2/hr.

As described in the same reference, Equation (1) was developed for the undisturbed natural and homogeneous soil, which should exclude the condition existing under Patch No. 1. The temperature data under Patches 4 and 5 should, however, be considered close to that for undisturbed soil. The best fit thermal diffusivity for these two grass covered patches agree with each other very well (0.019 for short grass and 0.021 for the long grass), which confirms the observations made in reference [2]. The calculated earth temperatures shown in Tables ST-4 and 5 for the grass covered patches also show very good agreement with the observed values. Since the temperatures under Patches 1, 2, and 3

are somewhat disturbed, caused by the fact that the surface conditions are different from those of surroundings, the mathematical model represented by equation (1) is not expected to fit the observed temperature very well. The agreement between the calculated and observed earth temperatures is not as good as that for Patches 4 and 5 as evidenced in Tables ST-1 and 2. A most dramic way of expressing the earth temperature change due to the disturbed surface condition is to plot the monthly average temperature against the depth as shown in Figure 10. Compared with the similar plot for Patch No. 4, (short grass covered) the temperature under the black surface show not only wider annual fluctuation but also higher average value.

Unusually large average temperature values for 10, 20 and 30 ft depths under the short grass covered surfaces shown in Figures P-45, 46 and 47 are believed to be the results of instrumentation error. If these errors are corrected, it can be said that the annual average temperature of the undisturbed earth at the NBS grounds should be 52 $\sim$ 53 °F at all the depths, which is the annual average air temperature as evident from Figure 5 and as expected from Equation (1).

The annual average temperatures under the black surface, however, show a trend of the depth dependency. It is approximately 5 °F higher than the undisturbed earth even at the depth of 20'. But at the 30' level, the black ground surface effect seems to disappear. It is expected, however, that there should have been some increase of the temperature under the black surface even at the 30 ft depth, had the paved area been much larger than the present 50' x 50'.

4. Diurnal Temperature Cycles

In order to study the diurnal variation in detail, two typical days were selected from summer and winter. Figures 12 through 16 are summer diurnal earth temperature profiles of Patches 1 through 5, respectively. Superimposed on each figure is the air temperature which was measured in the shaded and mechanically ventilated cubicle 4 ft above the ground surface. These figures show that the summer diurnal temperature stays relatively constant for depths beyond 1' for all the patches. The most interesting phenomena is the relative value of the earth temperature near the surface with respect to air temperature. The higher earth temperature compared with the air temperature during the middle of the day, particularly for Patch No. 1 is due to the solar heating. The higher air temperature compared with the ground temperature for Patches 2, 3, 4 and 5 during the middle of the night and early morning is due to the long wavelength radiation heat exchange with the sky. This sky radiation effect is most significant for Patch No. 5. The earth temperature near the surface of Patch No. 1, however, never becomes lower than the air temperature during the night and early morning. This was because enough solar heat was absorbed during the previous day so that the nighttime radiation loss to the sky was not sufficient to bring the earth surface temperature lower than the ambient air temperature.

On the other hand, by painting the asphalt surface white, the diurnal summer temperature profile of the paved surface (Patch No. 2) was decreased so that it was almost as cool as that of the bare ground surface as shown in Figures 10 and 11. Figures 15 and 16 show the diurnal cycles for temperature under the grass covered earth surface, and exhibit considerably different characteristics than for the other surfaces. The earth temperature is nearly constant at the depth of 1' and the surface temperatures show relatively sharp rises. The time of the peak temperature for the short grass patch (No. 4) was hour 15:00, and for the long grass (No. 5) was hour 13:00. The most plausible explanation for this discrepancy of the peak temperature hours is that the earth under the long grass was relatively insulated from the direct solar heating.

Figures 17 through 21 show the earth and air diurnal temperature profiles during a snow covered winter day for Patch No. 1 through 5, respectively. As expected the effect of solar heating was very small for all the patches and the earth temperature is relatively unaffected by the surface weather condition.

5. Probe Thermocouples vs. Direct Burial Thermocouples

For each patch, the one foot depth temperatures were measured by two thermocouples as described in the previous report. The first thermocouple was encased in a polyethylene tube probe (Figure 2) whereas the second one was directly buried outside the probe spreading horizontally outward 1 ft beneath the surface (Figure 22). The purpose of these two probes was to examine the heat conduction errors of temperature measurements due to the encasement of thermocouples in the probe. A similar but more extensive comparison of the probe thermocouples vs. direct burial thermocouples were made for Patch No. 3 at 30', 20', 10', 6', 4' and 1' depths. Good agreements of the temperatures measured by the probe thermocouples and direct burial thermocouples are indicated by comparing Figure P-5 with P-6, P-17 with P-18, P-30 with P-30A, P-31 with P-31A, P-33 with P-33A, P-34 with P-34A, P-35 with P-35A, P-36 with P-36A, P-41 with P-42 and P-53 with P-54.

These comparisons show rather conclusively that the probe thermocouples are as accurate as the direct burial thermocouples for the purpose of obtaining earth temperature data.

Moreover, it was expected that the direct burial thermocouples might be prone to pick up more spurious noise from the stray ground current than the probe thermocouples. The figures shown above also contradict this expectation. This may partly be due to the fact that the tips of the direct burial thermocouple, as well as the wires, were better protected than expected.

6. Heat Flux Data

Heat flow meter readings at the 4" depth under Patches 1, 2, 4, and 5 are shown respectively in Figures P-69, 70, 71 and 72. Unfortunately the heat flow meter failed for Patch No. 3 (bare surface). The heat flux values indicated in negatives in the above figures are those flowing downward and those indicated positive are flowing upward. As expected, the downward heat flow is very high during the daytime for the black surface (maximum of 25 $\sim$ 27 Btu/hr, ft^2) and low under the long grass (less than 10 Btu/hr, ft^2). The upward heat flow during the nighttime is also very high for the black surface reaching to more than 10 Btu/hr and very small for the long grass covered surface (less than 5 Btu/hr, ft^2).

While Figures P-69 and 70 indicate considerably smaller downward heat flow for the white surface than for the black, they both show almost the same amount of upward heat flow.

It is also apparent from Figures P-70 and 71 that the annual upward heat flow of the white surface and grass covered patches are balanced by the downward heat flow. Figure P-69 for the black surface patch, however, shows a considerable excess of downward heat flow. This inbalance of the black surface heat flow is an indication that the temperature underneath is continuously building up.

7. Solar Radiation Data

Shown in Figure P-73 is the hourly record of total hemispherical radiation incident upon the test site. The maximum values of nearly 370 Btu/hr, ft^2 were recorded during the summer, which is much higher than expected. The expected highest value of the total hemispherical radiation over the horizontal surfaces in the Washington, D. C. area is usually in the neighborhood of 300 Btu/hr. The cause of these high solar radiation values may be partly due to the fact that the solar radiation meter was receiving the reflected radiation from the surrounding objects.

8. Thermal Environment of the Instrument Bunker

The thermal environment inside the underground instrument bunker should be of extreme interest in view of the basic objective of this study. As described in the previous report, the bunker interior dimensions are 6' (w), 4' (l), and 7' (h) and the wall was 6" thick concrete. The bunker had an earth cover of 24" and was vented by a 4 inch

galvanized steel pipe. The internal heat generation due to the instruments was approximately 3 KW. During the preliminary trial runs conducted during the end of August, 1969, the interior air temperature exceeded 95 °F and the instruments started to fail. A 1/3 nominal ton air conditioner was installed to maintain interior temperature below 90 °F. Also noteworthy was dehumidification of the bunker during the summer. Condensate collected was approximately 4 gallons per week when the relative humidity of the bunker was maintained at approximately 40%.

For the day of June 28, for example, with the air conditioner in operation, both the bunker ceiling surface, and the floor surface temperature remained approximately constant at 80 °F. During the winter, the air conditioner was kept off and the ceiling and floor surface temperature for January 15 was constant at 55 °F.

9. Earth Temperature Record of the Preceding Year

Actual data recording started in the summer of 1968. Because of various difficulties, however, the automatic data acquisition did not start fully until February, 1969.

During this first year data were collected manually usually once a day at noon. The temperatures at 12" depth under Patches 1, 2 and 4 are shown in Figure 24. Patch No. 2 was not painted white until July 31, and it thus assumed the identical temperature as Patch No. 1 prior to that time.

It is interesting to see that the effect of the surface painting was immediately noticeable even at the one foot depth. Also interesting is the fact that the temperature under the grass covered surface is slightly higher than the paved surfaces during the winter, although it is approximately 20 °F lower than the black surface during the summer.

10. Summary

Earth temperatures beneath five different surfaces, namely, paved, paved and painted white, bare, short grass covered and long grass covered were measured hourly for a period of one year. The temperature data were obtained at the surface and at the depth of 1", 2", 4", 12", 24", 48", 72", 120", 240", 360". Complete hourly plots as well as the monthly average plots of the temperature data are provided in this report. The examination of these plots reveals the following:

1. Earth temperature is considerably affected by the asphalt paving. The annual variation as well as the average temperature under the paved black top surface is considerably higher than the non-paved surfaces as shown in Figures 8 and 9 and Table IV of the main text. By painting the paved surface white with regular highway paint, however, the earth temperature increase due to solar heating can be reduced considerably. In effect, the white surface yielded earth temperatures practically the same as those of the bare surfaces.

The surface which was covered by long grass yielded the lowest earth temperature, but the difference in earth temperatures at all depths was very small between the long grass and short grass covered surfaces.

The ground surface temperature became lower than the ambient air temperature during the summer night with clear sky except for the black paved surface, which soaked up too much heat during the previous day to be sufficiently cooled off.

Even during the summer, however, the diurnal temperature wave did not penetrate beyond the two foot depth. The annual wave, however, did reach the 30' depth.

2. Despite the rain and fairly prolonged snow cover during the test period, the earth moisture content at the 4' depth did not materially change, indicating that the surface had a good drainage.

3. Temperature indicated by thermocouples encased in a 1" polyethylene tube packed with Ottawa sand agreed very well with those directly buried in the soil.

4. The underground instrument bunker of 10' x 6' x 7' with earth cover of 2' did require approximately a 1/3 ton air conditioner to maintain temperature below 90 °F during the summer period. The bunker was equipped with an automatic data logging device, reference thermocouple junction, telemetering equipment and lighting, all of which produced approximately 2 KW of heat. The temperature seldom exceeded 60 °F, however, during the winter period.

5. By using a least squares technique, earth thermal diffusivity of the site was estimated to be 0.02 ft^2/hr.

11. Acknowledgment

The major work on the construction and installation of the instrumentation system, as well as the day to day data management, was done by J. D. Allen, without whose consistent and diligent attendance to detail, this project could not have been successful. The author also wishes to express gratitude to Mr. W. Carroll for his work in processing the vast amount of paper punch tape and for producing beautiful annual plots.

12. References

1. Black, J. F., Weather Control: Use of Asphalt Coating to Tap Solar Energy, Science Vol, 139, pp. 226-227.
2. Kusuda, T. and Powell, F. J., An Automated Earth Temperature Station (Instrumentation), NBS Report 10223, 1970.
3. Kusuda, T., Least Squares Technique for the Analysis of Periodic Temperature of the Earth's Surface Region, NBS Journal of Research, Vol. 71C, January-March, 1967, pp. 43-50.
4. Kusuda, T., Least Squares Analysis of Annual Earth Temperature Cycles for Selected Stations in the Contiguous United States, NBS Report 9493, 1967.

Table I

Channel No.	Sensor	Location
0	Reference Volt	Within the IDVM
1	Thermocouple	30 ft under Patch No. 1
2	"	20 " " " " "
3	"	10 " " " " "
4	"	6 " " " " "
5	"	4 " " " " "
6	"	2 " " " " "
7	"	1 " " " " "
8	"	12 in. " " " "
9	"	4 " " " " "
10	"	2 " " " " "
11	"	1 " " " " "
12	"	0 " " " " "
13	"	30 ft under Patch No. 2
14	"	20 " " " " "
15	"	10 " " " " "
16	"	6 " " " " "
17	"	4 " " " " "
18	"	2 " " " " "
19	"	1 " " " " "

Table 1 - Continued

Channel No.	Sensor	Location
20	Thermocouple	12 in. under Patch No. 2
21	"	4 " " " " "
22	"	2 " " " " "
23	"	1 " " " " "
24	"	0 " " " " "
25	"	30 ft under Patch No. 3
26	"	20 " " " " "
27	"	10 " " " " "
28	"	6 " " " " "
29	"	4 " " " " "
30	"	2 " " " " "
31	"	1 " " " " "
32	"	12 in. under Patch No. 3
33	"	4 " " " " "
34	"	2 " " " " "
35	"	1 " " " " "
36	"	0 " " " " "
37	"	30 ft under Patch No. 3
38	"	20 " " " " "
39	"	10 " " " " "
40	"	6 " " " " "

Table 1 - Continued

Channel No.	Sensor	Location
41	Thermocouple	4 ft under Patch No. 3
42	"	2 " " " " "
43	"	1 " " " " "
44	"	30 ft under Patch No. 4
45	"	20 " " " " "
46	"	10 " " " " "
47	"	6 " " " " "
48	"	4 " " " " "
49	"	2 " " " " "
50	"	1 " " " " "
51	"	12 in. under Patch No. 4
52	"	4 " " " " "
53	"	2 " " " " "
54	"	1 " " " " "
55	"	0 " " " " "
56	"	30 ft under Patch No. 5
57	"	20 " " " " "
58	"	10 " " " " "
59	"	6 " " " " "
60	"	4 " " " " "

Table 1 - Continued

Channel No.	Sensor	Location
61	Thermocouple	2 ft under Patch No. 5
62	"	1 " " " " "
63	"	12 in. under Patch No. 5
64	"	4 " " " " "
65	"	2 " " " " "
66	"	1 " " " " "
67	"	0 " " " " "
68	"	Zone Box within the Bunker
69	"	Inside Surface of the Bunker Wall
70	"	Inside Surface of the Bunker Ceiling
71	"	Inside Surface of the Bunker Floor
72	"	Outside Surface of the Bunker Wall
73	"	Approximately 2 ft under the Ground Surface and 4 ft away from the Bunker
74	"	Ground Surface right above the Bunker
75	"	2 ft above the Ground over the Bunker

Table 1 - Continued

Channel No.	Sensor	Location
76	Thermocouple	Wet-bulb Temperature of Outside Air
77	"	Dry-bulb Temperature of Outside Air
78	"	Air Temperature 12 ft above the Ground Surface
79	"	
80	Solar Pyronometer	
81	"	
82	"	
83	Wind Direction	
84	Windspeed	
85	Heatflow Meter	4 in. under Patch No. 1
86	"	4 in. under Patch No. 2
87	"	18 in. under Patch No. 3
88	"	12 in. under Patch No. 3
89	"	4 in. under Patch No. 3
90	"	2 in. under Patch No. 3
91	"	4 in. under Patch No. 4
92	"	4 in. under Patch No. 5
93	Thermocouple	Replacement for Channel 26
94	Rain Gage	Above the Bunker
95	Rain Gage	Above the Bunker

Table 1 - Continued

Channel No.	Sensor	Location
96	Thermocouple	Chassis of the Data Logger
97	Ultra-violet Radiation	Above the Bunker
98		
99		

Table II

WEEK OF 3 28 69
REMARKS
DATE 3 / 1 TIME 030

CHAN NO	MV	DATA	REMARK	CHAN NO	MV	DATA	REMARK
0	1000.6800	1000.0	REF	50	-2.6258	36.0	T
1	-2.2002	55.5	T	51	-2.6430	35.2	T
2	-2.1875	56.1	T	52	-2.6459	35.0	T
3	-2.3214	50.0	T	53	-2.6285	35.8	T
4	-2.4495	44.1	T	54	-2.6302	35.8	T
5	-2.5253	40.6	T	55	-2.7088	32.1	T
6	-2.5646	38.8	T	56	-2.2683	52.4	T
7	-2.5078	41.4	T	57	-2.2591	52.8	T
8	-2.5007	41.8	T	58	-2.6428	35.2	T
9	-2.4893	42.3	T	60	-2.5594	39.1	T
10	-2.5341	40.2	T	61	-2.6151	36.5	T
11	-2.5443	39.8	T	62	-2.6376	35.4	T
12	-2.6294	35.8	T	63	-2.3717	47.7	T
13	-2.2108	55.0	T	64	-2.6408	35.3	T
14	-2.2284	54.2	T	65	-2.6386	35.4	T
15	-2.7376	30.8	T	66	-2.6474	35.0	T
16	-2.5196	40.9	T	67	-2.7307	31.1	T
17	-2.6043	37.0	T	68	.9690	76.0	T
18	-2.7007	32.5	T	69	.0003	76.1	T
19	-2.7415	30.6	T	70	-.3963	58.3	T
20	-2.3939	46.7	T	71	-.3343	61.1	T
21	-2.7513	30.1	T	72	-.4719	54.9	T
22	-2.7522	30.1	T	73	-.7769	40.9	T
23	-2.7563	29.9	T	74	-.9358	33.6	T
24	-2.7647	29.5	T	75	-.1606	24.5	T
25	-2.2394	53.7	T	76	.0770	35.6	T
27	-2.6423	35.2	T	77	.1224	37.7	T
28	-2.5590	39.1	T	78	-.1557	24.7	T
29	-2.6468	35.0	T	79	.0003	.0	**
30	-2.6141	36.5	T	80	.0196	1.9	SOL
31	-2.6470	35.0	T	81	.0003	.0	SOL
32	-2.4477	44.2	T	82	.5610	.0	SOL
33	-2.6509	34.8	T	83	2.1950	NW	WDD
34	-2.6688	34.0	T	84	.0327	7.0	WDV
35	-2.6851	33.2	T	85	1.0172	1.5	HF
36	-2.7122	31.9	T	86	-.1995	-.3	HF
37	-2.1903	56.0	T	87	1.2179	1.7	HF
38	-2.2699	52.4	T	88	.0010	.0	HF
39	-2.4465	44.3	T	89	.7775	1.2	HF
40	-2.5599	39.0	T	90	-7.2002	-10.4	HF
42	-2.6527	34.7	T	91	.5786	.8	HF
43	-2.6532	34.7	T	92	.5562	.8	HF
44	-2.2441	53.5	T	93	-2.2782	52.0	T
45	-2.2431	53.6	T	94	2.3222	2.3	
46	-2.3516	48.6	T	95	.0922	2.9	RAIN
47	-2.4594	43.7	T	96	1.9934	64.9	REF
48	-2.5336	40.3	T	97	1.9043	2.1	UVR
49	-2.5988	37.2	T	98	.0002	.0	***
				99	.0003	.0	***

Figure 30

Table III Compares the Annual Range and the Annual Average of the Temperature Under Black Surface and Under Natural Grass Covered Surface

Depth	Annual Extremes Max.	Min.	Avg.	Annual Extremes Max.	Min.	Avg.
0'	91	28	60	75	30	53
1'	87	32	60	68	34	51
2'	84	33	59	68	36	52
3'	81	36	59	66	38	52
4'	79	37	58	64	39	52
6'	75	43	59	63	42	53
8'	71	46	58	62	44	53
10'	68	48	58	61	48	55
20'	60	53	57	56	51	54
30'	55	51	53	56	52	54

EARTH TEMPERATURE STATION PATCH NO1
TYPE OF SOIL
TYPE OF EARTH SURFACE
DATA PROCESSED BY
DATA SOURCE
PERIOD OF OBSERVATION

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
12.0	34.0	32.0	39.0	53.0	68.0	81.0	87.0	86.0	85.0	77.0	60.0	43.0
24.0	36.0	33.0	39.0	51.0	64.0	77.0	84.0	84.0	83.0	76.0	62.0	46.0
48.0	43.0	37.0	40.0	47.0	58.0	69.0	77.0	79.0	79.0	76.0	66.0	53.0
72.0	48.0	43.0	43.0	47.0	54.0	63.0	70.0	74.0	75.0	74.0	69.0	58.0
120.0	56.0	49.0	48.0	48.0	51.0	56.0	61.0	66.0	68.0	68.0	68.0	63.0
240.0	58.0	56.0	55.0	54.0	53.0	53.0	53.0	55.0	57.0	58.0	60.0	59.0
360.0	56.0	56.0	56.0	55.0	54.0	53.0	52.0	52.0	53.0	54.0	55.0	55.0

RESULTS OF LEAST SQUARES ANALYSIS

PREDICTED EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
12.0	31.8	30.3	35.9	48.2	62.9	77.0	85.9	87.7	81.5	69.5	54.3	40.7
24.0	35.6	32.9	36.7	46.7	59.7	72.9	82.0	85.1	80.9	71.0	57.5	44.8
48.0	42.5	38.1	39.0	45.4	55.1	66.2	75.0	79.7	78.7	72.4	62.3	51.6
72.0	48.3	43.1	42.0	45.5	52.4	61.3	69.3	74.8	75.8	72.4	65.2	56.5
120.0	56.2	51.2	48.3	48.1	50.8	55.8	61.5	66.6	69.7	69.8	66.9	62.1
240.0	61.7	60.1	58.2	56.4	55.3	55.2	56.1	57.8	59.8	61.6	62.6	62.7
360.0	60.2	60.2	60.0	59.4	58.7	58.1	57.7	57.7	58.0	58.5	59.2	59.8

M= 84.
N= 1
D= .0315

FOURIER COEFFICIENTS FOR THE LEAST SQUARES FORMULATION

A0	A1	A2	A3	A4	B1	B2	B3	B4
58.959	-22.835	-22.875						

STANDARD DEVIATION OF FOURIER COEFFICIENTS

.3435 .8482 .8472

EARTH TEMPERATURE STATION PATCH NO2
TYPE OF SOIL
TYPE OF EARTH SURFACE
DATA PROCESSED BY
DATA SOURCE
PERIOD OF OBSERVATION

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
12.0	31.0	29.0	31.0	43.0	55.0	65.0	72.0	73.0	69.0	63.0	50.0	36.0
24.0	34.0	32.0	32.0	41.0	53.0	62.0	68.0	72.0	68.0	64.0	53.0	40.0
48.0	40.0	37.0	37.0	41.0	49.0	57.0	63.0	67.0	67.0	65.0	57.0	47.0
72.0	45.0	42.0	40.0	38.0	46.0	53.0	58.0	63.0	64.0	63.0	60.0	52.0
120.0	51.0	47.0	47.0	45.0	46.0	49.0	53.0	57.0	59.0	59.0	60.0	57.0
240.0	55.0	54.0	53.0	52.0	51.0	50.0	50.0	51.0	52.0	54.0	56.0	56.0
360.0	53.0	53.0	54.0	54.0	53.0	53.0	52.0	51.0	51.0	53.0	55.0	54.0

RESULTS OF LEAST SQUARES ANALYSIS

PREDICTED EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
12.0	31.1	29.4	33.4	42.7	54.3	65.7	73.2	75.2	70.9	61.7	49.7	38.7
24.0	34.6	31.9	34.2	41.6	51.6	62.1	69.6	72.7	70.1	62.8	52.4	42.3
48.0	40.7	36.7	36.7	40.9	47.9	56.4	63.5	67.8	67.8	63.6	56.2	48.0
72.0	45.6	41.2	39.7	41.5	46.1	52.5	58.7	63.4	64.9	63.1	58.2	51.9
120.0	51.7	47.9	45.3	44.5	45.7	48.8	52.7	56.6	59.3	60.1	58.7	55.7
240.0	54.4	53.6	52.5	51.3	50.4	49.9	50.1	50.9	52.1	53.3	54.2	54.6
360.0	52.8	53.0	53.0	52.8	52.5	52.1	51.8	51.6	51.6	51.8	52.1	52.5

M= 84.
N= 1
D= .0248

FOURIER COEFFICIENTS FOR THE LEAST SQUARES FORMULATION

A0	A1	A2	A3	A4	B1	B2	B3	B4
52.285	-17.681	-19.028						

STANDARD DEVIATION OF FOURIER COEFFICIENTS

.1259	.3234	.3231

EARTH TEMPERATURE STATION PATCH NO3
TYPE OF SOIL
TYPE OF EARTH SURFACE
DATA PROCESSED BY
DATA SOURCE
PERIOD OF OBSERVATION

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
1.0	29.0	29.0	32.0	45.0	58.0	70.0	77.0	76.0	73.0	66.0	50.0	36.0
4.0	31.0	29.0	33.0	45.0	58.0	70.0	76.0	76.0	73.0	66.0	51.0	37.0
12.0	34.0	32.0	33.0	43.0	55.0	65.0	72.0	73.0	71.0	67.0	55.0	42.0
24.0	41.0	37.0	37.0	39.0	47.0	57.0	64.0	67.0	68.0	66.0	57.0	47.0
48.0	37.0	33.0	34.0	42.0	52.0	62.0	68.0	71.0	69.0	66.0	57.0	45.0
72.0	43.0	39.0	39.0	42.0	47.0	55.0	61.0	65.0	66.0	65.0	62.0	52.0
120.0	49.0	46.0	43.0	43.0	47.0	51.0	55.0	59.0	61.0	63.0	62.0	56.0
240.0	55.0	53.0	51.0	50.0	49.0	50.0	51.0	52.0	53.0	55.0	59.0	57.0
360.0	53.0	53.0	52.0	52.0	53.0	53.0	52.0	52.0	51.0	53.0	56.0	55.0

RESULTS OF LEAST SQUARES ANALYSIS

PREDICTED EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
1.0	30.8	29.1	33.4	43.3	55.5	67.5	75.2	77.2	72.5	62.8	50.2	38.7
4.0	31.5	29.6	33.6	43.0	54.9	66.7	74.5	76.7	72.4	63.1	50.8	39.4
12.0	33.4	30.9	34.0	42.4	53.5	64.7	72.6	75.4	72.0	63.7	52.3	41.4
24.0	36.1	32.9	34.8	41.8	51.6	62.1	70.0	73.4	71.3	64.4	54.2	44.0
48.0	40.8	36.7	36.8	41.3	48.8	57.7	65.2	69.6	69.4	64.9	57.1	48.4
72.0	44.8	40.3	39.1	41.6	47.1	54.4	61.2	66.0	67.2	64.6	58.9	51.8
120.0	50.6	46.3	43.8	43.7	46.1	50.5	55.5	60.0	62.6	62.6	60.1	55.7
240.0	55.5	53.7	51.7	50.1	49.3	49.5	50.7	52.6	54.7	56.2	57.0	56.8
360.0	54.7	54.5	54.0	53.2	52.4	51.8	51.6	51.8	52.4	53.1	53.9	54.5

M= 108.
N= 1
D= .0429

FOURIER COEFFICIENTS FOR THE LEAST SQUARES FORMULATION

A0 A1 A2 A3 A4 B1 B2 B3 B4

53.152 -14.727 -19.465

STANDARD DEVIATION OF FOURIER COEFFICIENTS

.2053 .4128 .4121

EARTH TEMPERATURE STATION PATCH NO 4
TYPE OF SOIL
TYPE OF EARTH SURFACE
DATA PROCESSED BY
DATA SOURCE
PERIOD OF OBSERVATION

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
.0	31.0	30.0	32.0	44.0	54.0	67.0	73.0	75.0	69.0	64.0	51.0	39.0
1.0	32.0	31.0	33.0	43.0	54.0	65.0	71.0	73.0	70.0	65.0	55.0	41.0
4.0	34.0	32.0	33.0	42.0	52.0	62.0	69.0	73.0	69.0	64.0	54.0	31.0
12.0	36.0	34.0	35.0	41.0	48.0	57.0	64.0	68.0	68.0	65.0	58.0	48.0
24.0	41.0	36.0	37.0	41.0	47.0	54.0	62.0	66.0	68.0	65.0	60.0	49.0
48.0	46.0	39.0	39.0	41.0	46.0	52.0	57.0	62.0	64.0	64.0	62.0	53.0
72.0	49.0	43.0	42.0	43.0	46.0	49.0	53.0	58.0	62.0	63.0	62.0	57.0
120.0	53.0	49.0	48.0	47.0	47.0	48.0	51.0	53.0	57.0	58.0	61.0	58.0
240.0	54.0	53.0	53.0	53.0	52.0	51.0	51.0	51.0	52.0	53.0	56.0	56.0
360.0	53.0	53.0	53.0	53.0	53.0	53.0	52.0	52.0	52.0	53.0	56.0	54.0

RESULTS OF LEAST SQUARES ANALYSIS

PREDICTED EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
.0	33.0	30.4	33.3	41.5	52.4	63.6	71.5	74.4	71.2	63.1	51.8	41.0
1.0	33.4	30.6	33.4	41.4	52.1	63.3	71.2	74.2	71.1	63.2	52.1	41.4
4.0	34.4	31.4	33.7	41.2	51.4	62.2	70.1	73.4	70.9	63.5	52.8	42.4
12.0	37.0	33.4	34.6	40.7	49.7	59.8	67.6	71.4	70.0	64.0	54.6	44.9
24.0	40.5	36.3	36.2	40.5	47.8	56.6	64.1	68.5	68.5	64.2	56.6	48.0
48.0	46.1	41.5	39.8	41.3	45.7	52.1	58.4	63.2	65.1	63.5	58.8	52.6
72.0	50.1	45.8	43.3	43.1	45.3	49.6	54.5	58.9	61.6	61.7	59.3	55.2
120.0	54.1	51.3	48.9	47.2	47.0	48.3	50.6	53.5	56.1	57.6	57.8	56.5
240.0	53.8	53.7	53.3	52.6	51.9	51.3	51.1	51.1	51.6	52.2	52.9	53.5

M= 120.
N= 1
D= .0186

FOURIER COEFFICIENTS FOR THE LEAST SQUARES FORMULATION

A0	A1	A2	A3	A4	B1	B2	B3	B4
52.408	-11.359	-18.671						

STANDARD DEVIATION OF FOURIER COEFFICIENTS

.1712	.3496	.3490

EARTH TEMPERATURE STATION PATCH NO 5
TYPE OF SOIL
TYPE OF EARTH SURFACE
DATA PROCESSED BY
DATA SOURCE
PERIOD OF OBSERVATION

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
.0	28.0	28.0	30.0	45.0	53.0	66.0	69.0	69.0	61.0	57.0	47.0	33.0
1.0	33.0	32.0	32.0	42.0	50.0	59.0	66.0	67.0	63.0	59.0	51.0	41.0
4.0	35.0	33.0	33.0	41.0	49.0	57.0	63.0	67.0	63.0	59.0	52.0	41.0
12.0	37.0	33.0	33.0	40.0	48.0	56.0	62.0	65.0	63.0	60.0	53.0	45.0
24.0	39.0	35.0	36.0	40.0	47.0	53.0	59.0	63.0	63.0	61.0	57.0	47.0
48.0	43.0	38.0	39.0	41.0	45.0	50.0	56.0	59.0	62.0	61.0	59.0	51.0
120.0	52.0	48.0	47.0	46.0	46.0	47.0	49.0	52.0	55.0	57.0	61.0	57.0
240.0	53.0	53.0	52.0	52.0	51.0	50.0	49.0	49.0	51.0	53.0	56.0	55.0
360.0	52.0	52.0	52.0	53.0	52.0	52.0	51.0	51.0	51.0	53.0	54.0	53.0

RESULTS OF LEAST SQUARES ANALYSIS

PREDICTED EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
.0	33.4	31.4	34.2	41.5	51.0	60.6	67.2	69.4	66.4	59.2	49.4	40.1
1.0	33.7	31.6	34.3	41.5	50.8	60.3	66.9	69.2	66.3	59.3	49.6	40.4
4.0	34.5	32.2	34.5	41.2	50.2	59.5	66.1	68.6	66.1	59.5	50.2	41.2
12.0	36.6	33.8	35.2	40.8	48.8	57.4	64.0	67.1	65.5	60.0	51.7	43.3
24.0	39.5	36.1	36.4	40.5	47.1	54.8	61.1	64.7	64.4	60.3	53.4	45.9
48.0	44.2	40.4	39.2	40.9	45.1	50.9	56.4	60.4	61.7	59.9	55.5	49.9
120.0	51.5	48.8	46.7	45.4	45.5	46.9	49.3	52.0	54.3	55.5	55.3	53.9
240.0	51.6	51.6	51.1	50.4	49.7	49.2	49.0	49.3	49.8	50.5	51.2	51.7
360.0	50.6	50.7	50.8	50.8	50.7	50.5	50.3	50.2	50.1	50.1	50.2	50.4

M= 108.
N= 1
D= .0210

FOURIER COEFFICIENTS FOR THE LEAST SQUARES FORMULATION

A0	A1	A2	A3	A4	B1	B2	B3	B4
50.451	-10.313	-15.988						

STANDARD DEVIATION OF FOURIER COEFFICIENTS

.2083 .4086 .4078

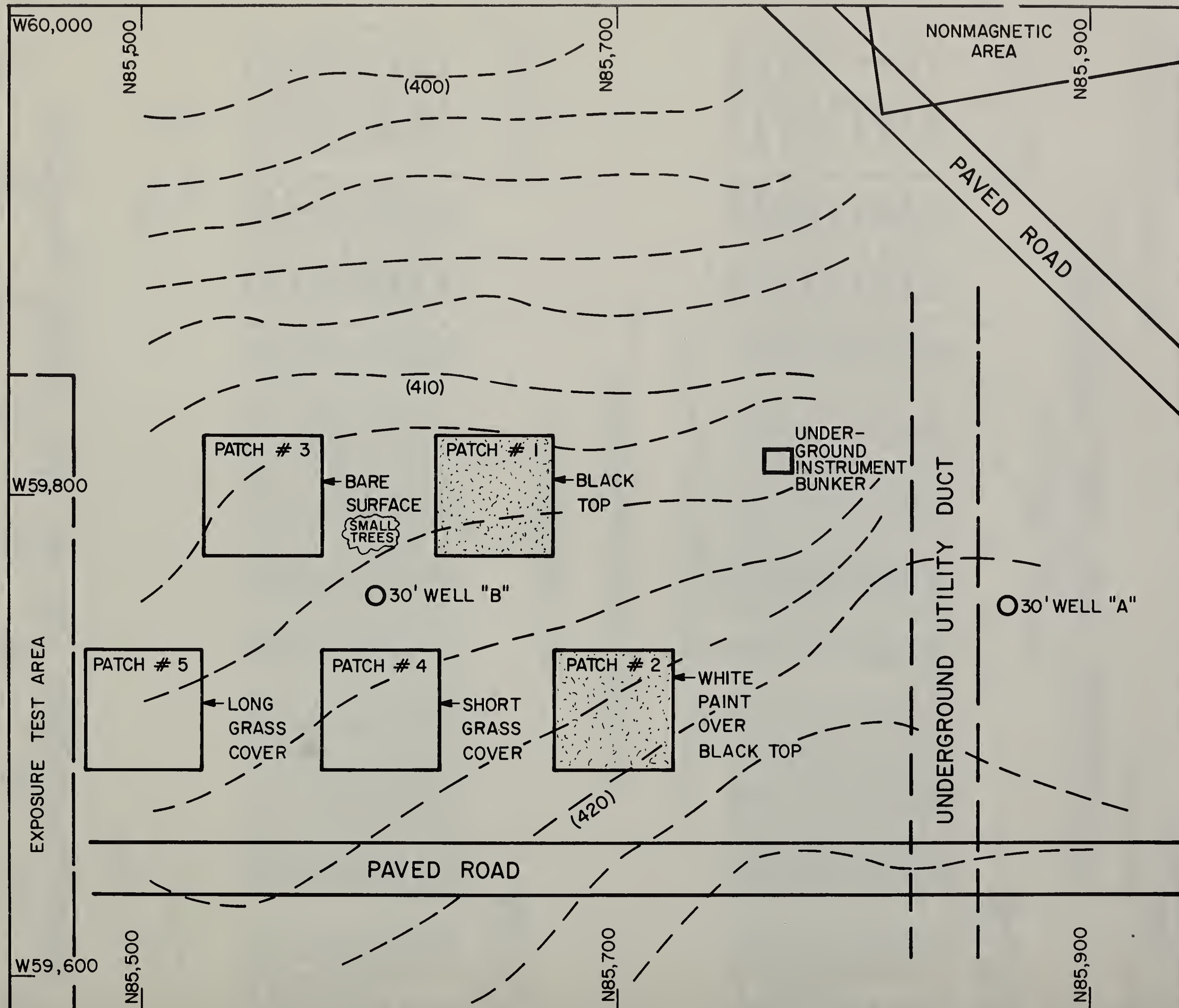


Figure 1 Earth Temperature Site on NBS Grounds

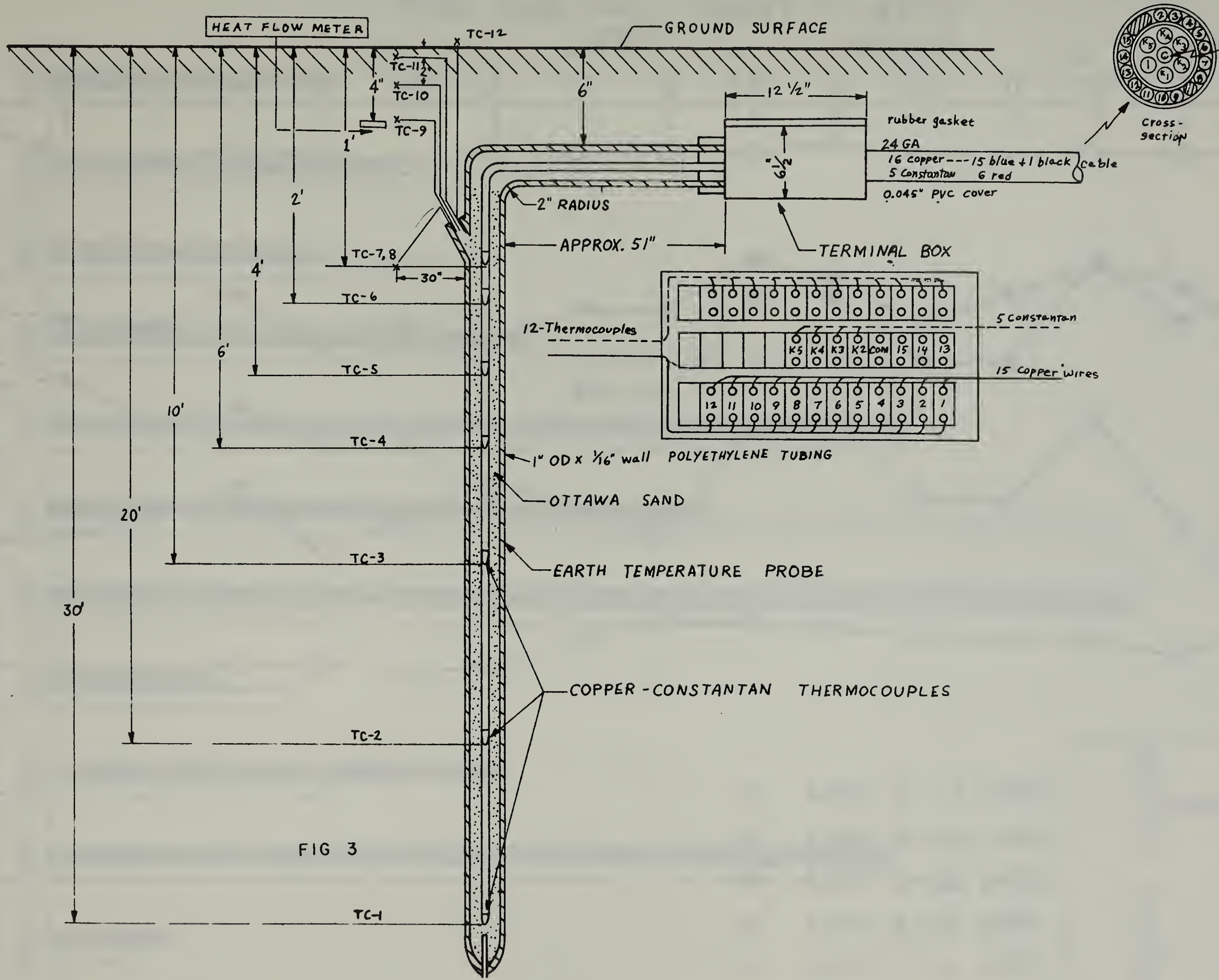


Figure 2 Earth Temperature Probe

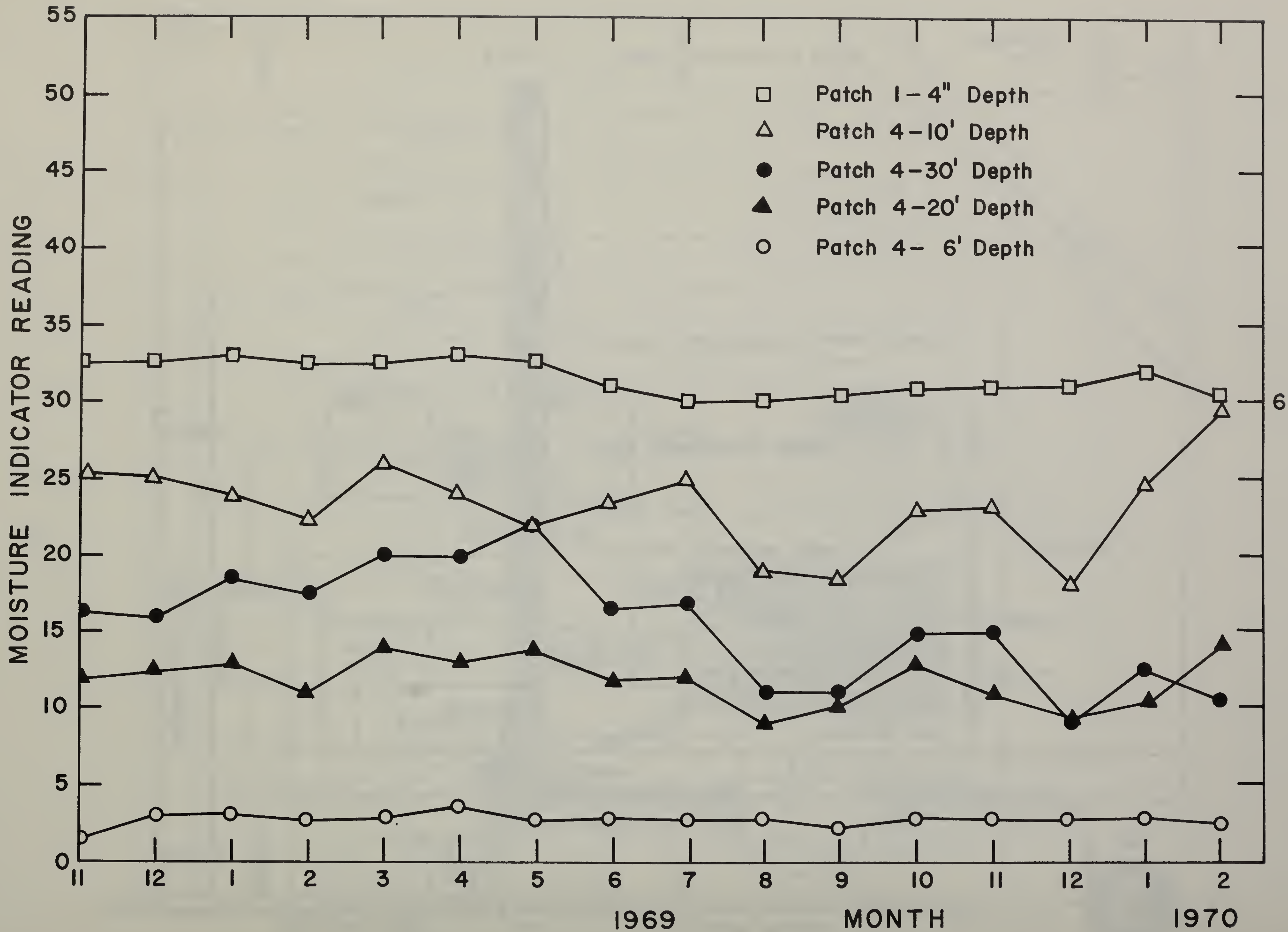


Figure 3 Soil Moisture Change During the Test Period

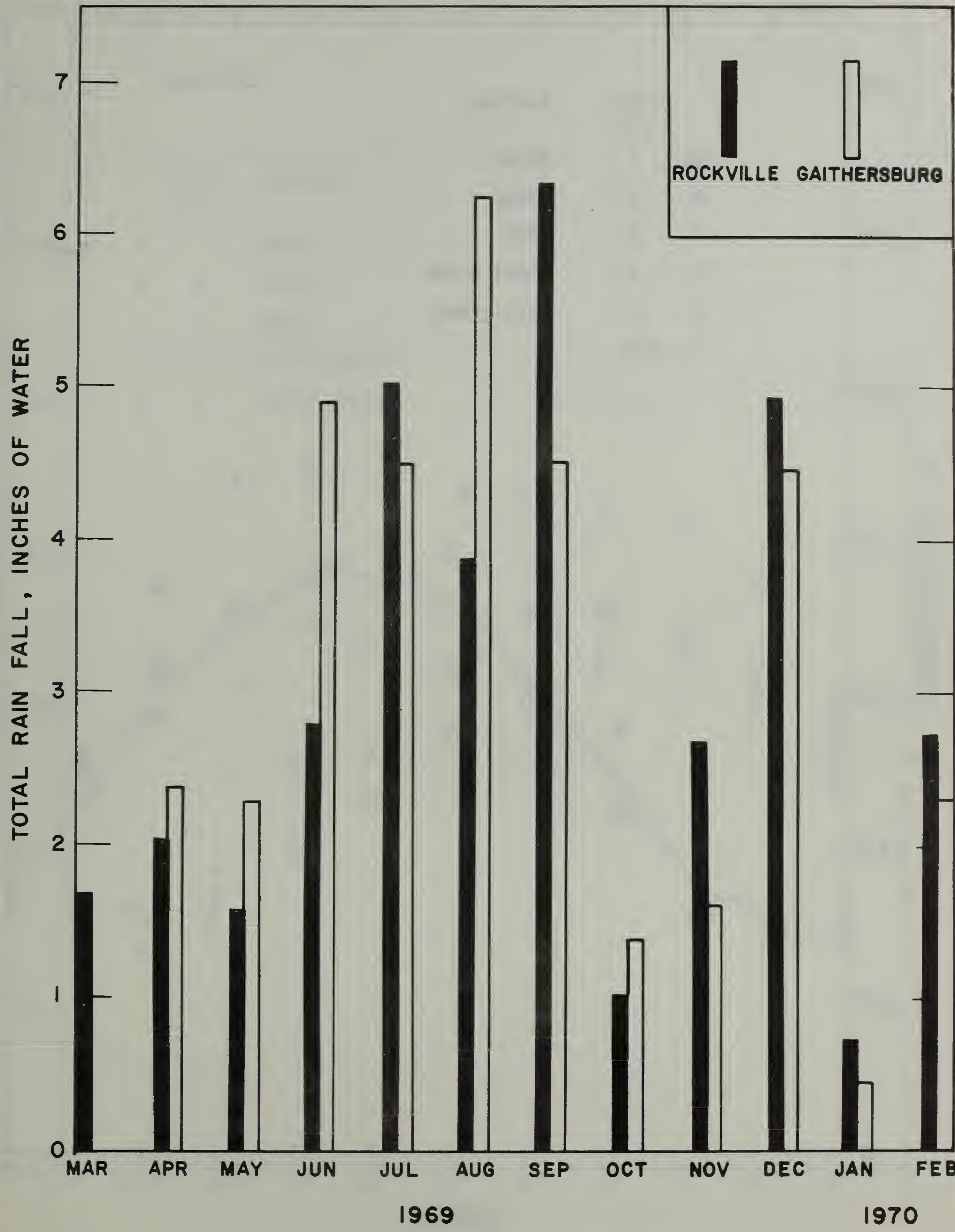


Figure 4 Monthly Rainfall Profile During the Test Period

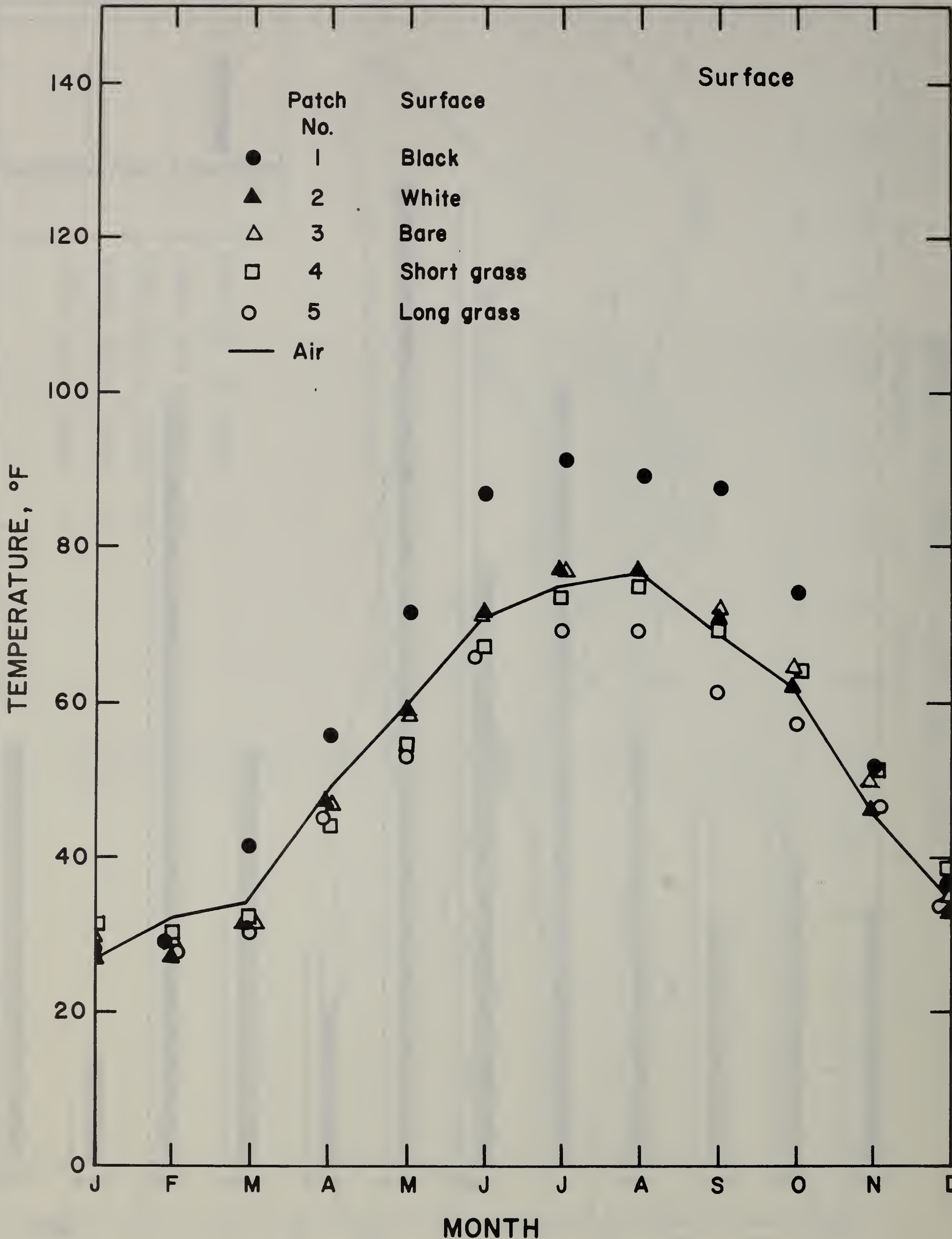


Figure 5 Monthly Average Surface Temperatures of Five Patches

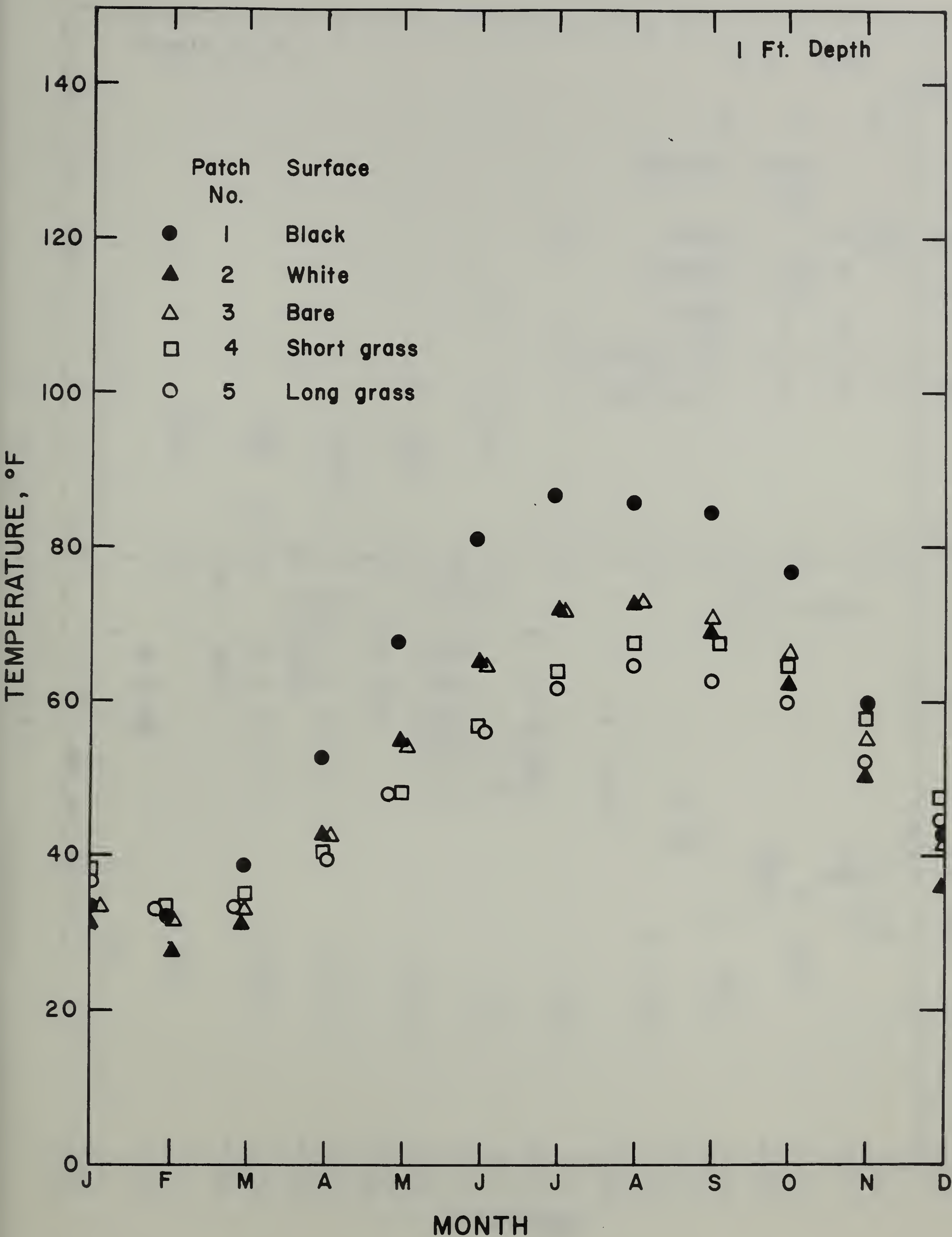


Figure 6 Monthly Average Earth Temperatures at 1 ft Depth

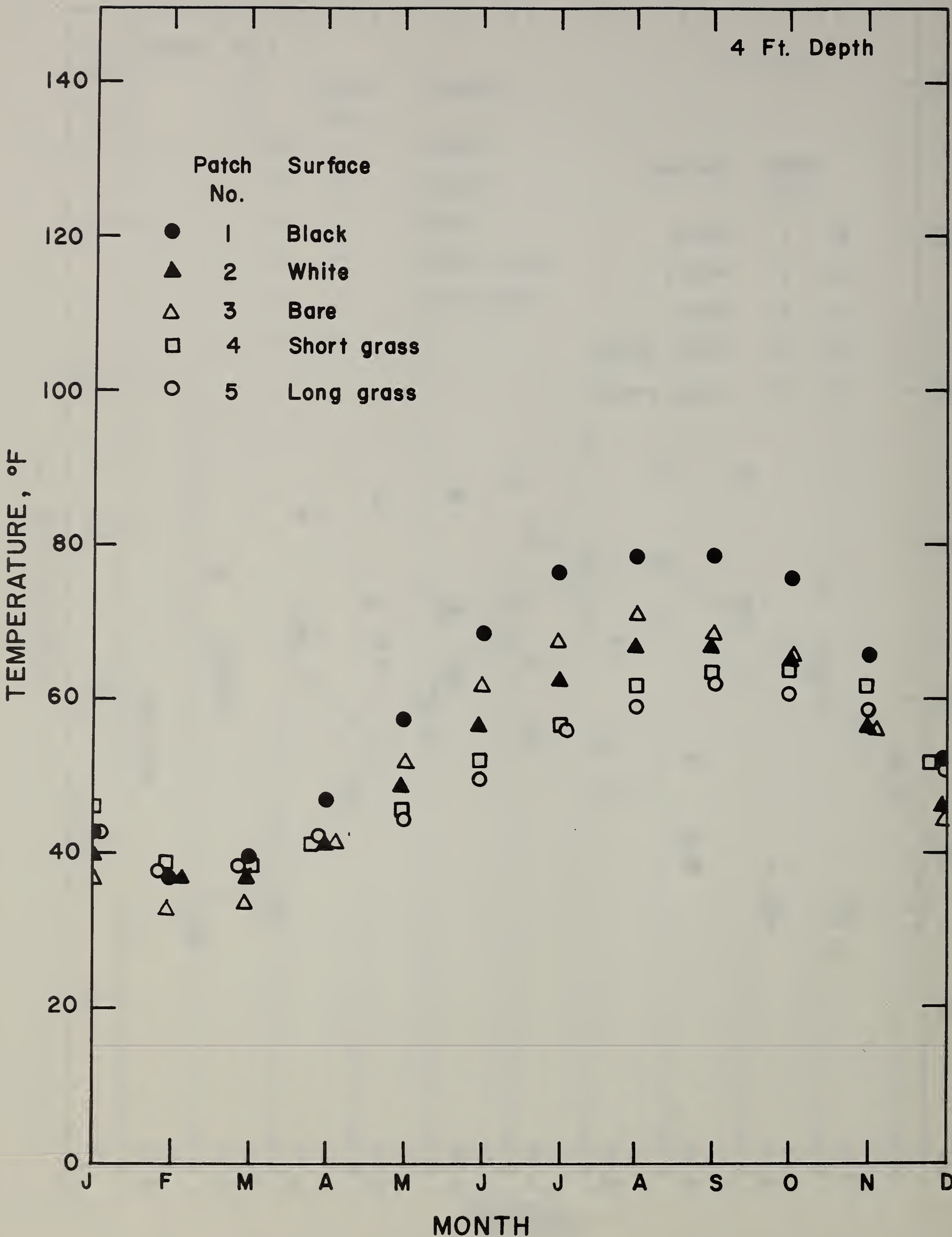


Figure 7 Monthly Average Earth Temperatures at 4 ft Depth

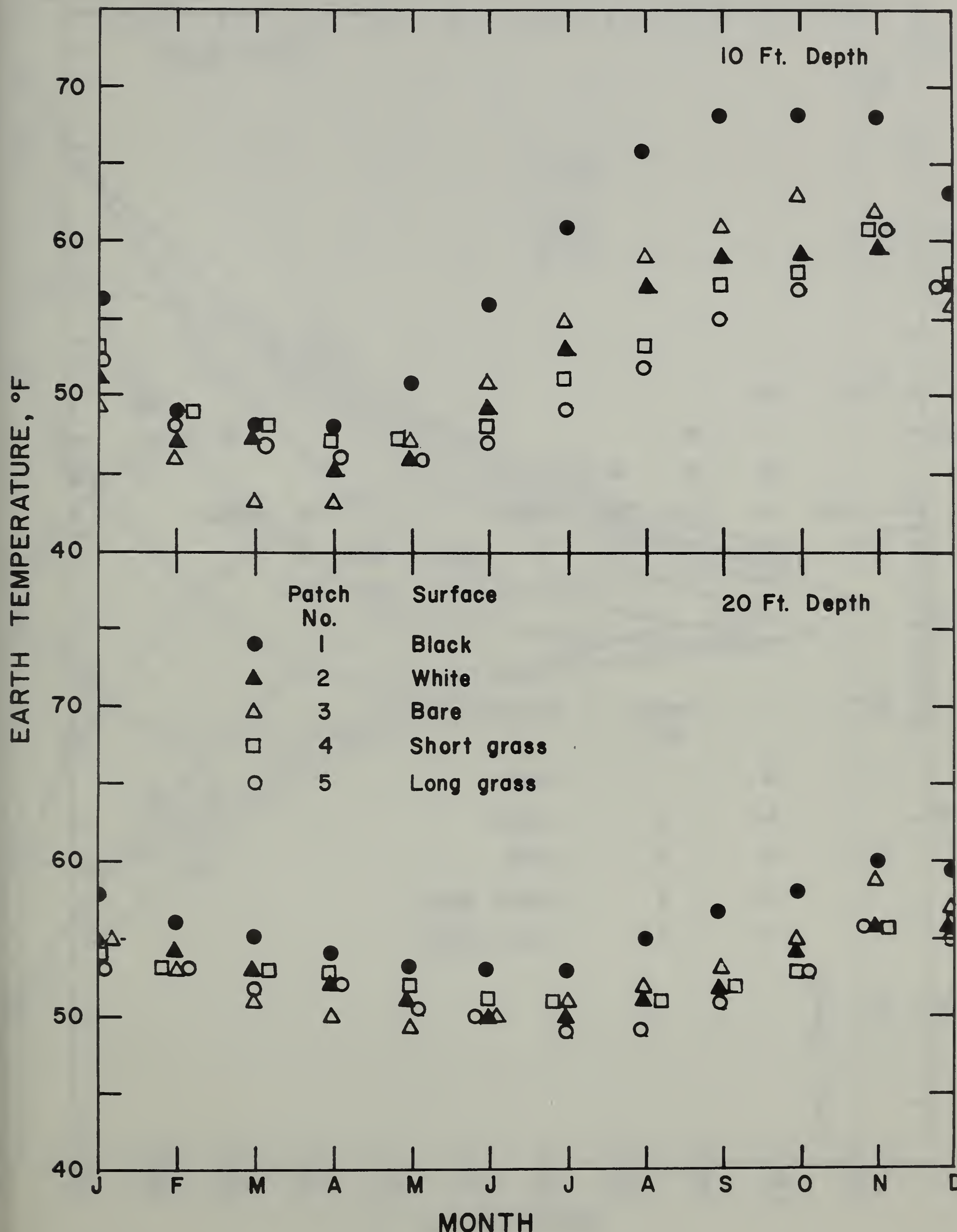


Figure 8 Monthly Average Earth Temperatures at 10 and 20 ft Depth

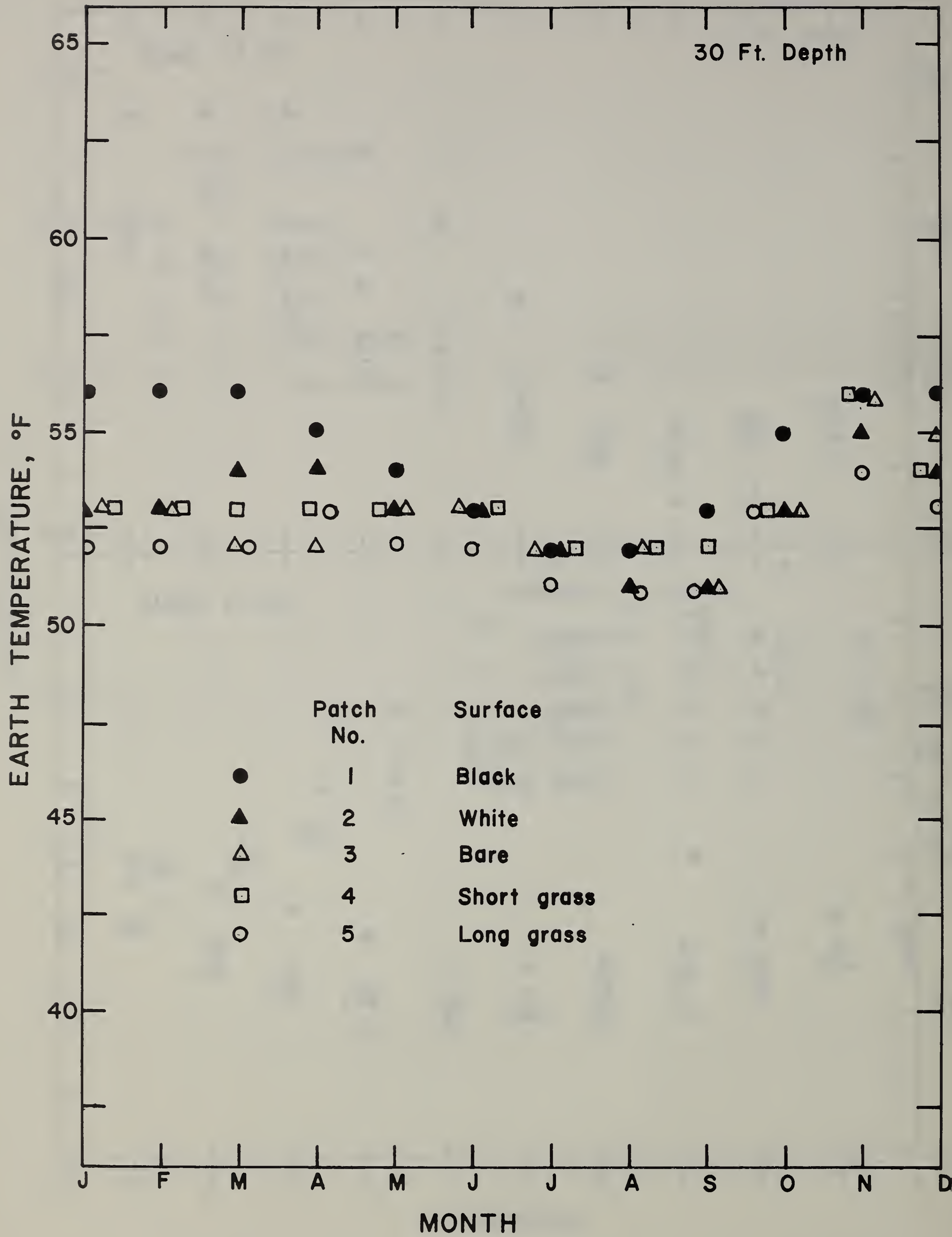


Figure 9 Monthly Average Earth Temperatures at 30 ft Depth

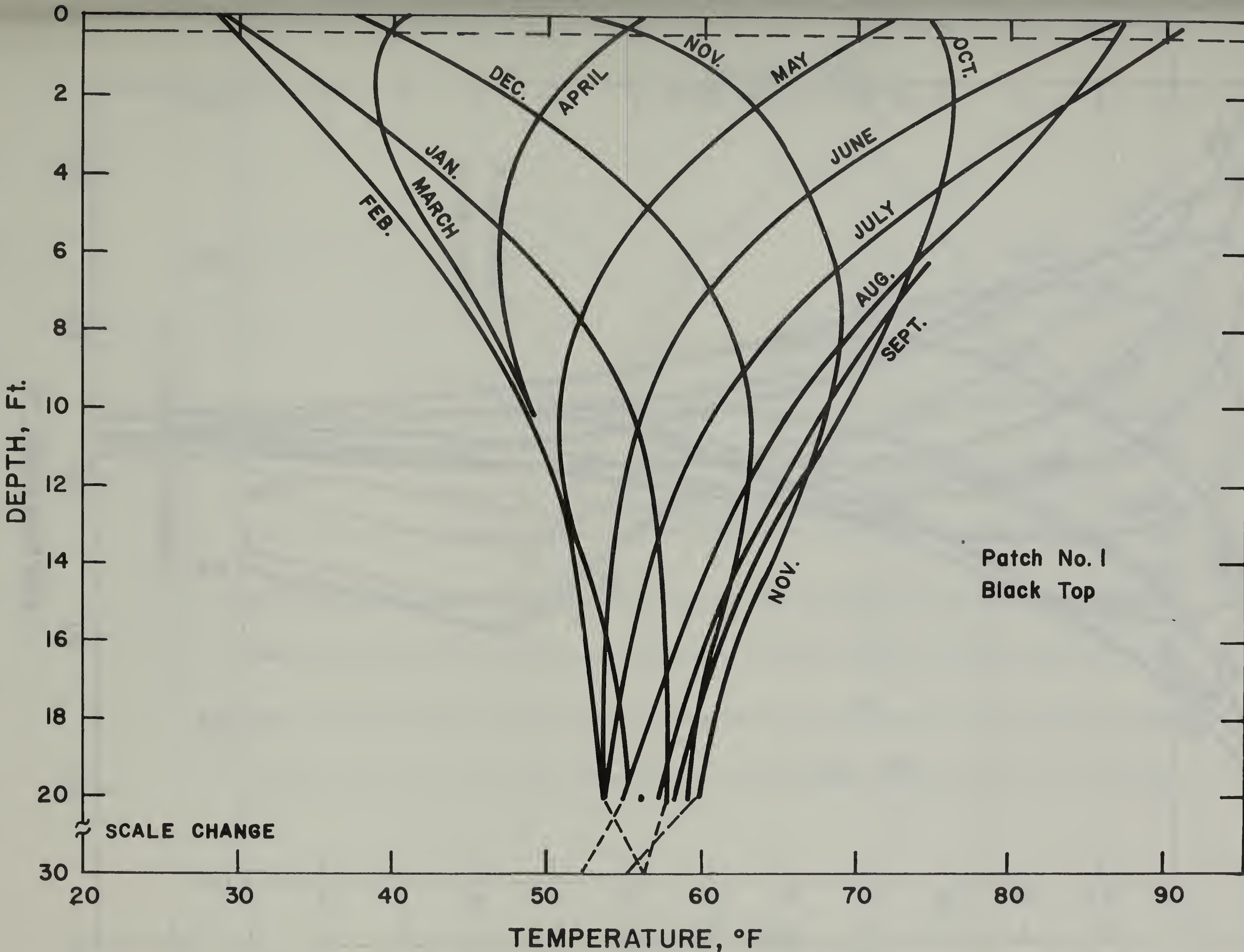


Figure 10 Monthly Average Earth Temperature at Various Depths for Patch No. 1 (black surface)

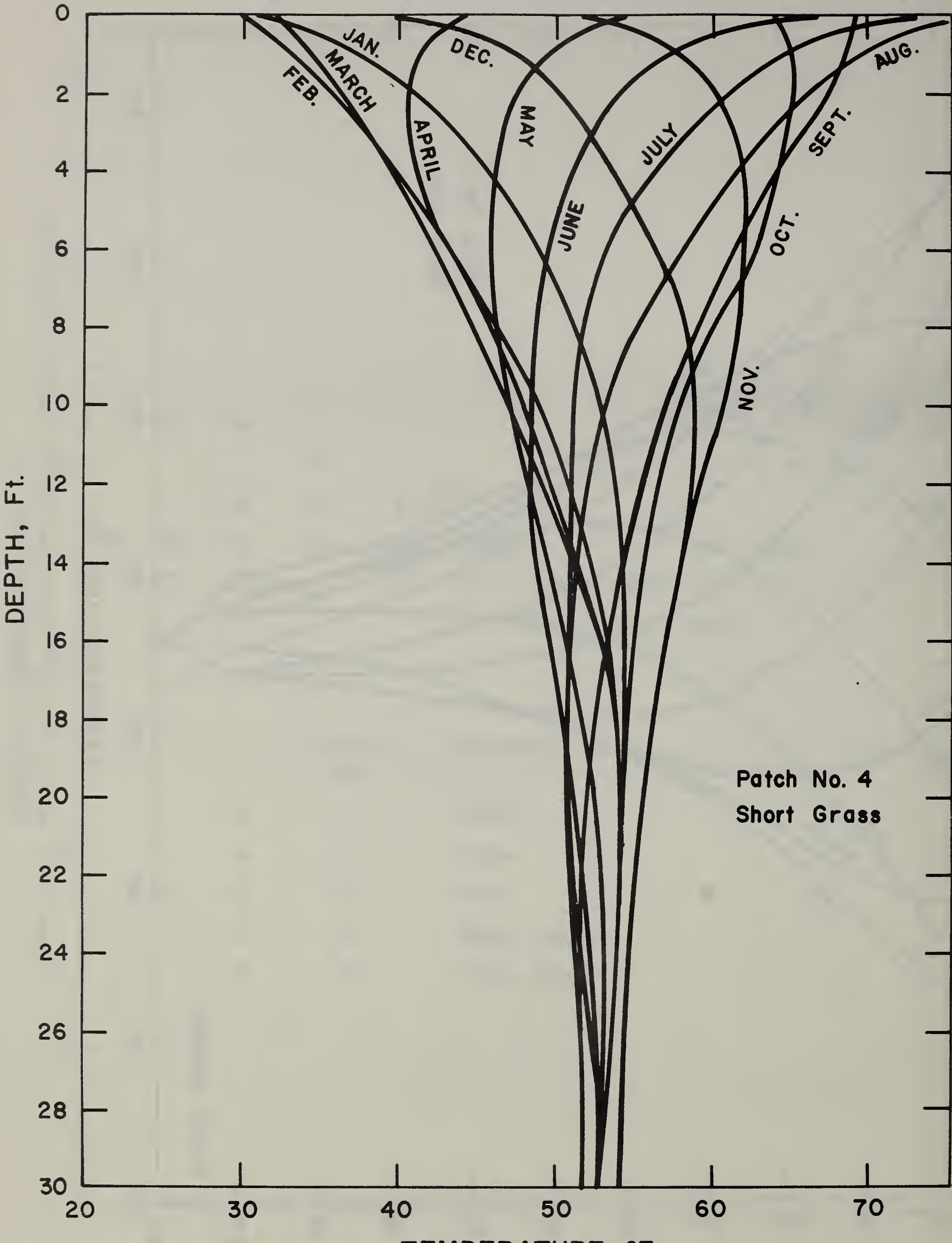


Figure 11 Monthly Average Earth Temperature at Various Depths for Patch No. 4 (short grass)

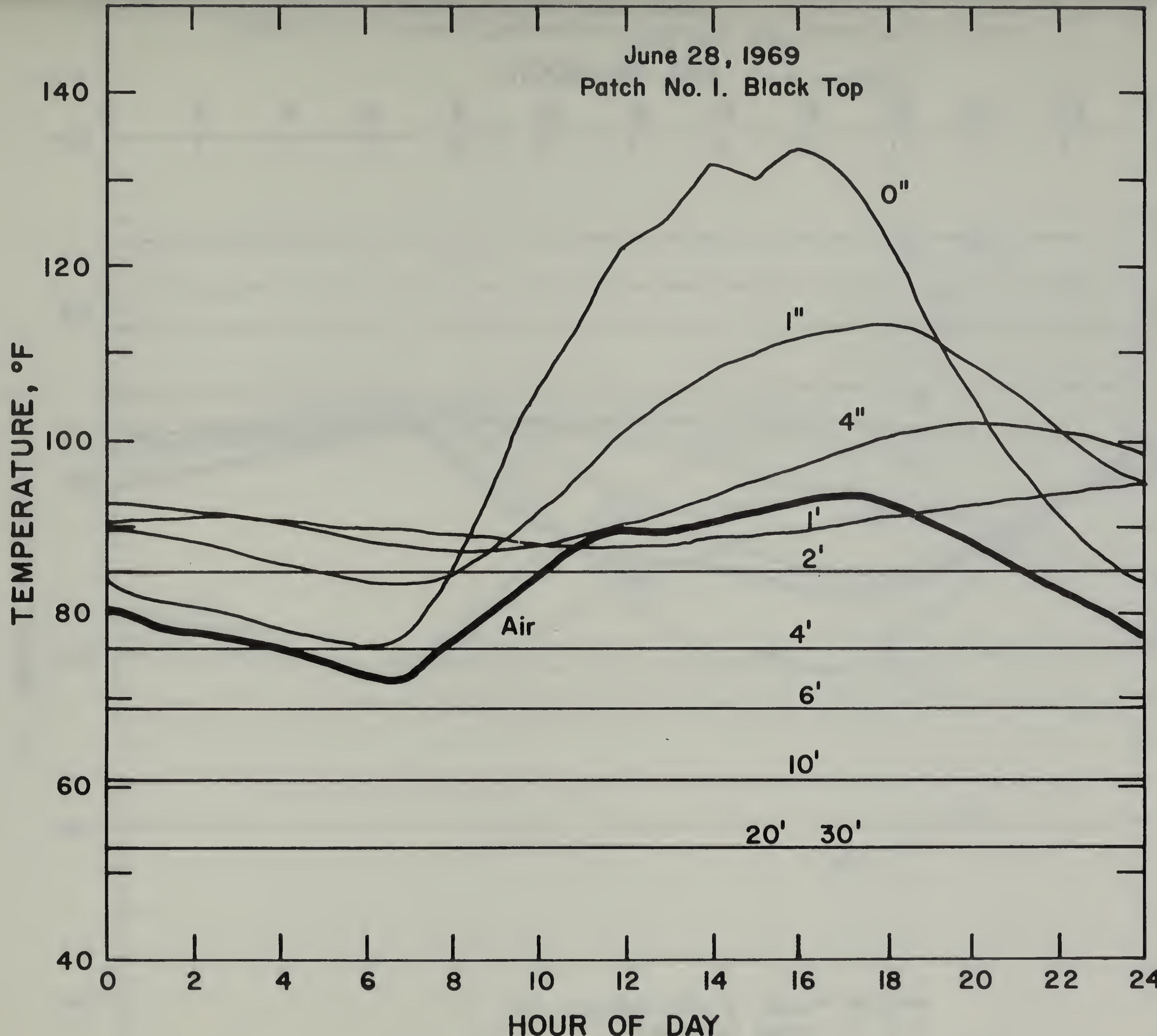


Figure 12 Diurnal Temperature Variation for Patch No. 1 (black surface) on June 28, 1969

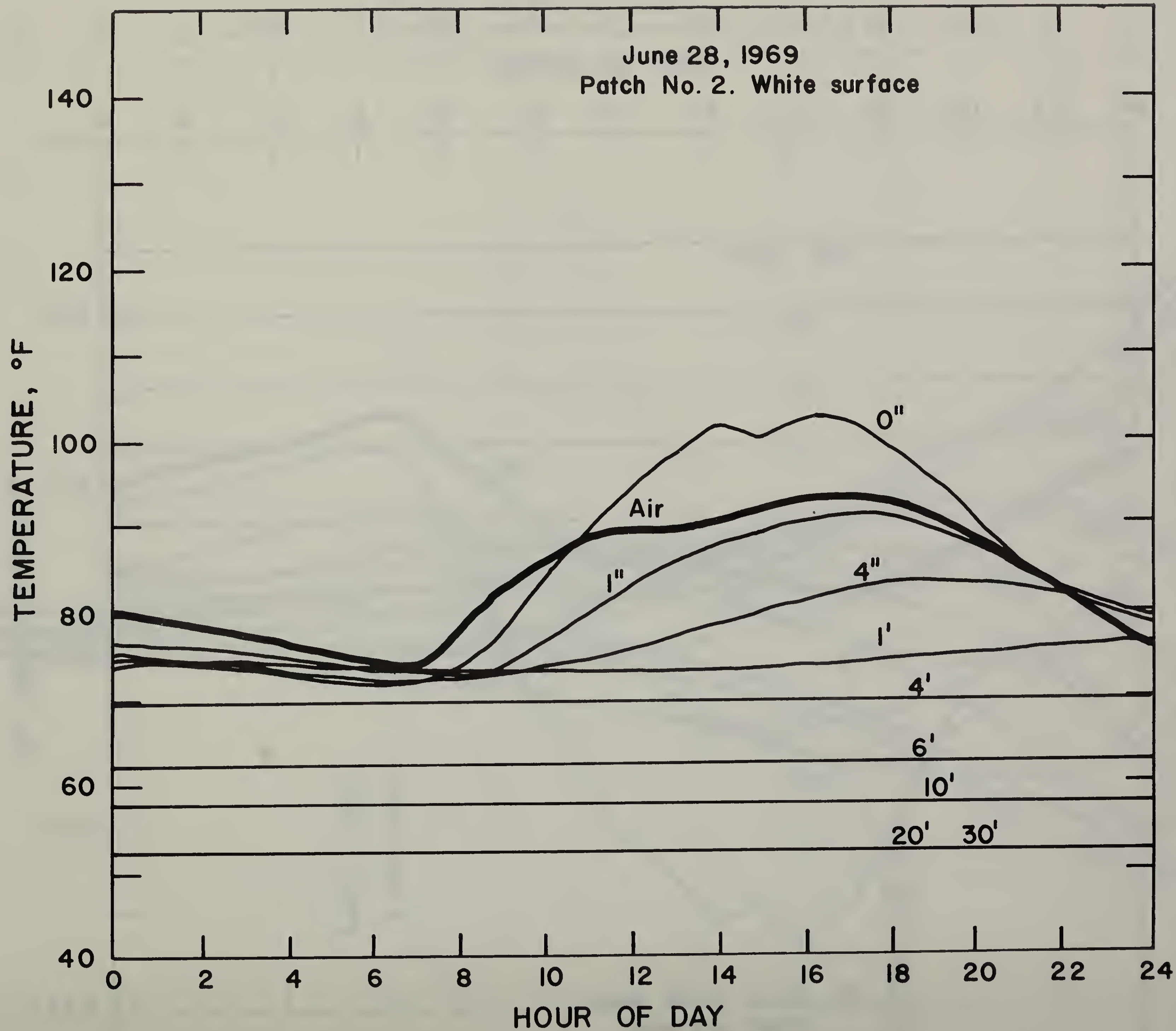


Figure 13 Diurnal Temperature Variation for Patch No. 2 (white surface) on June 28, 1969

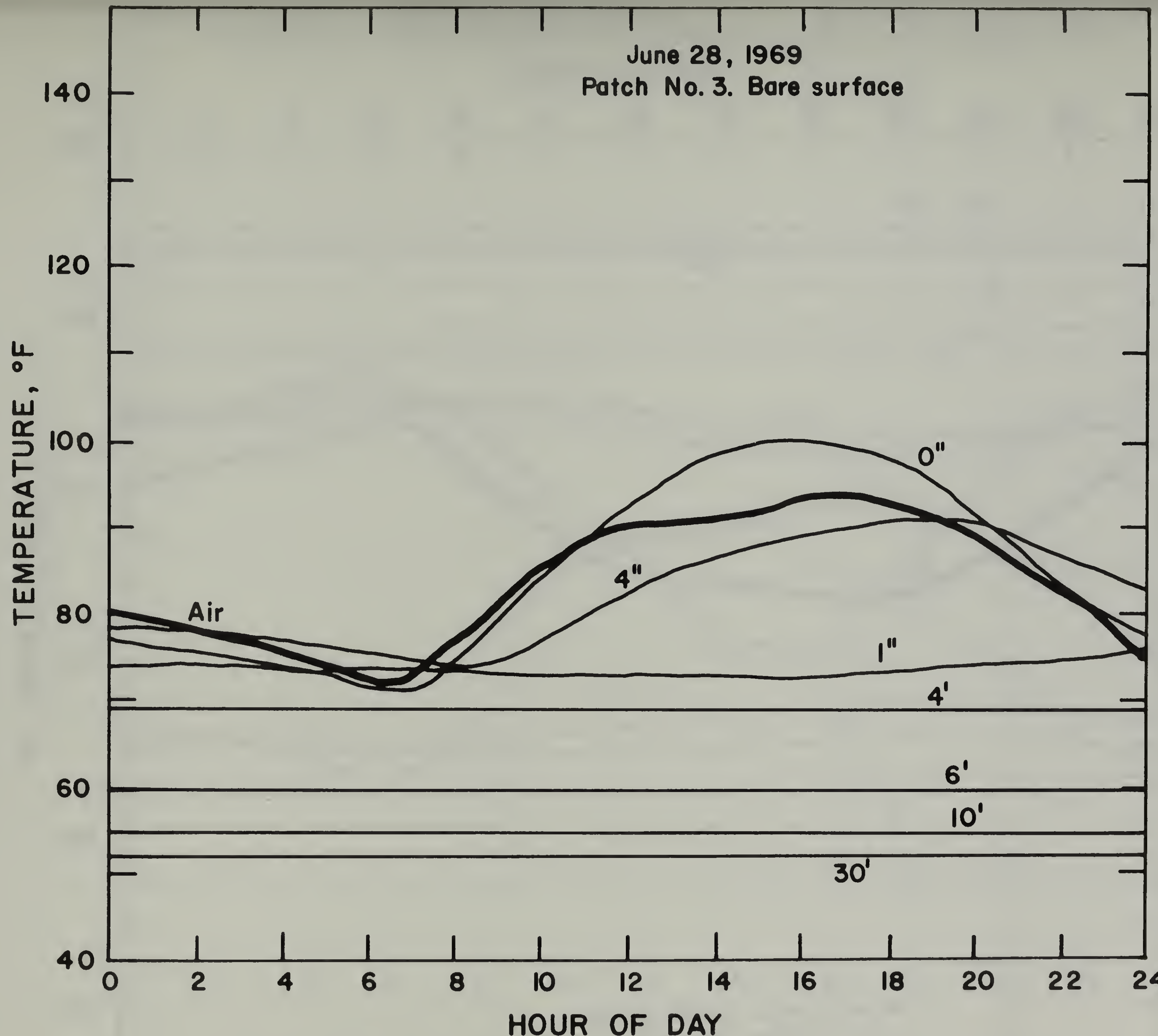


Figure 14 Diurnal Temperature Variation for Patch No. 3 (bare surface) on June 28, 1969

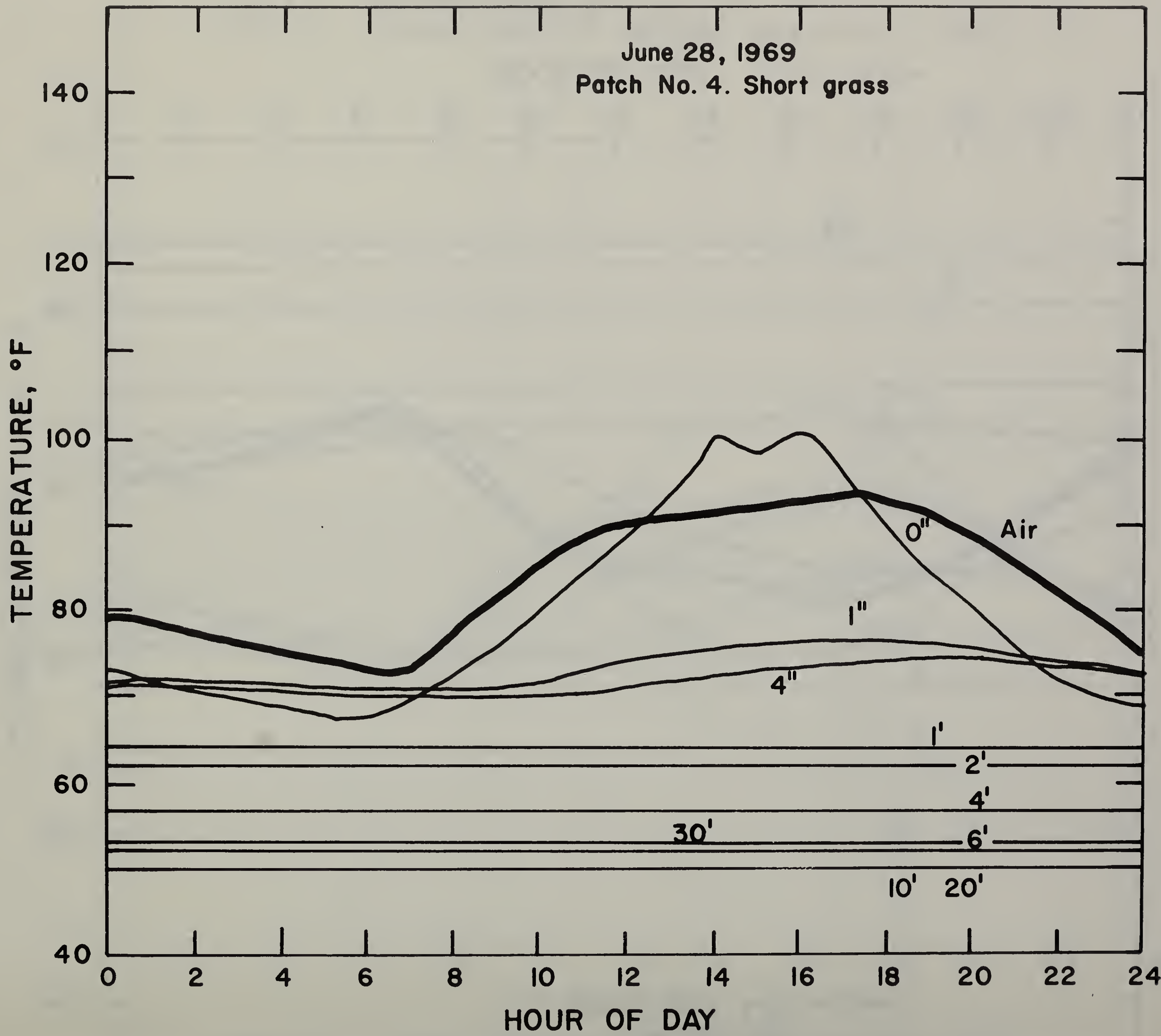


Figure 15 Diurnal Temperature Variation for Patch No. 4 (short grass) on June 28, 1969

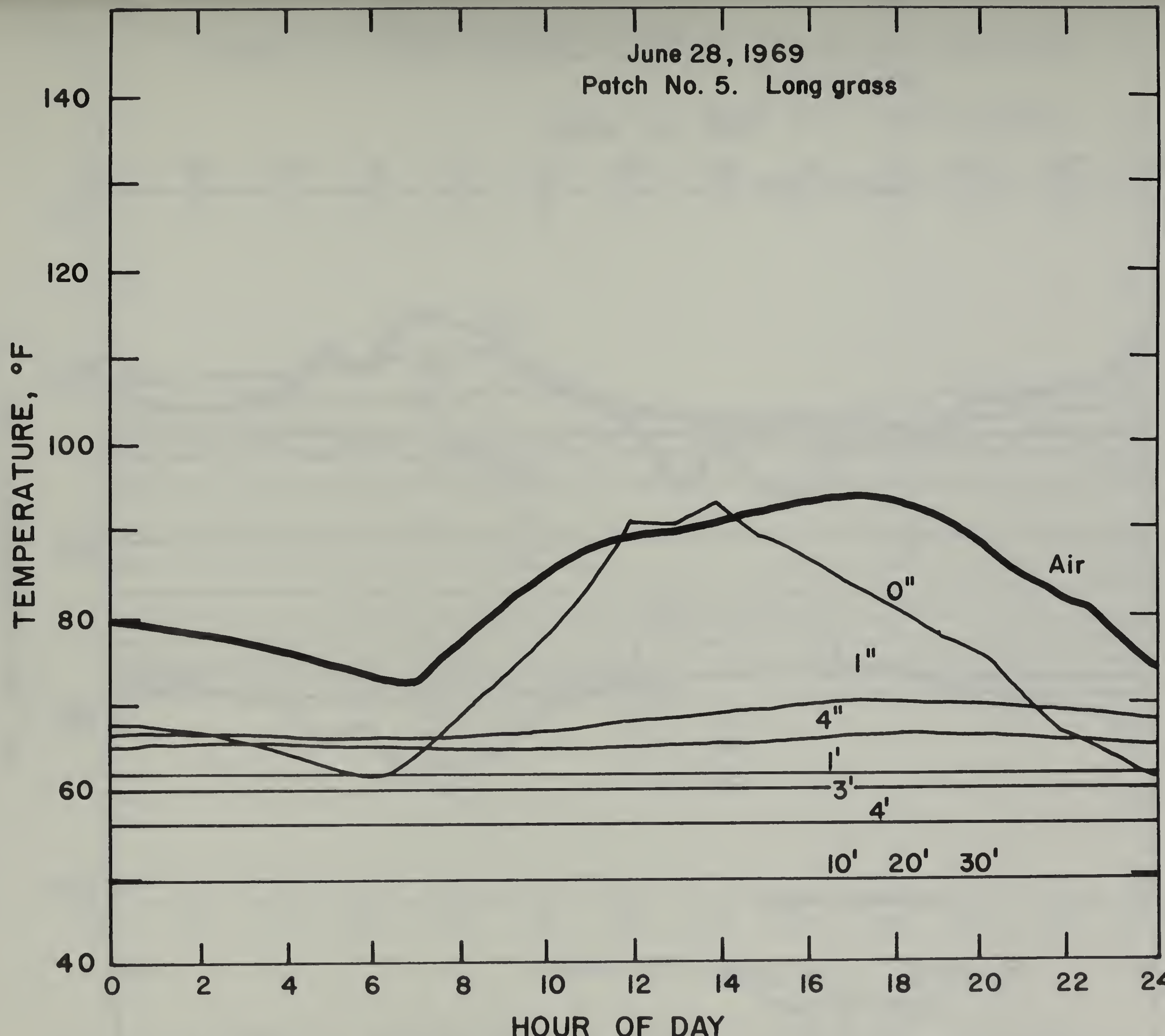


Figure 16 Diurnal Temperature Variation for Patch No. 5 (long grass) on June 28, 1969

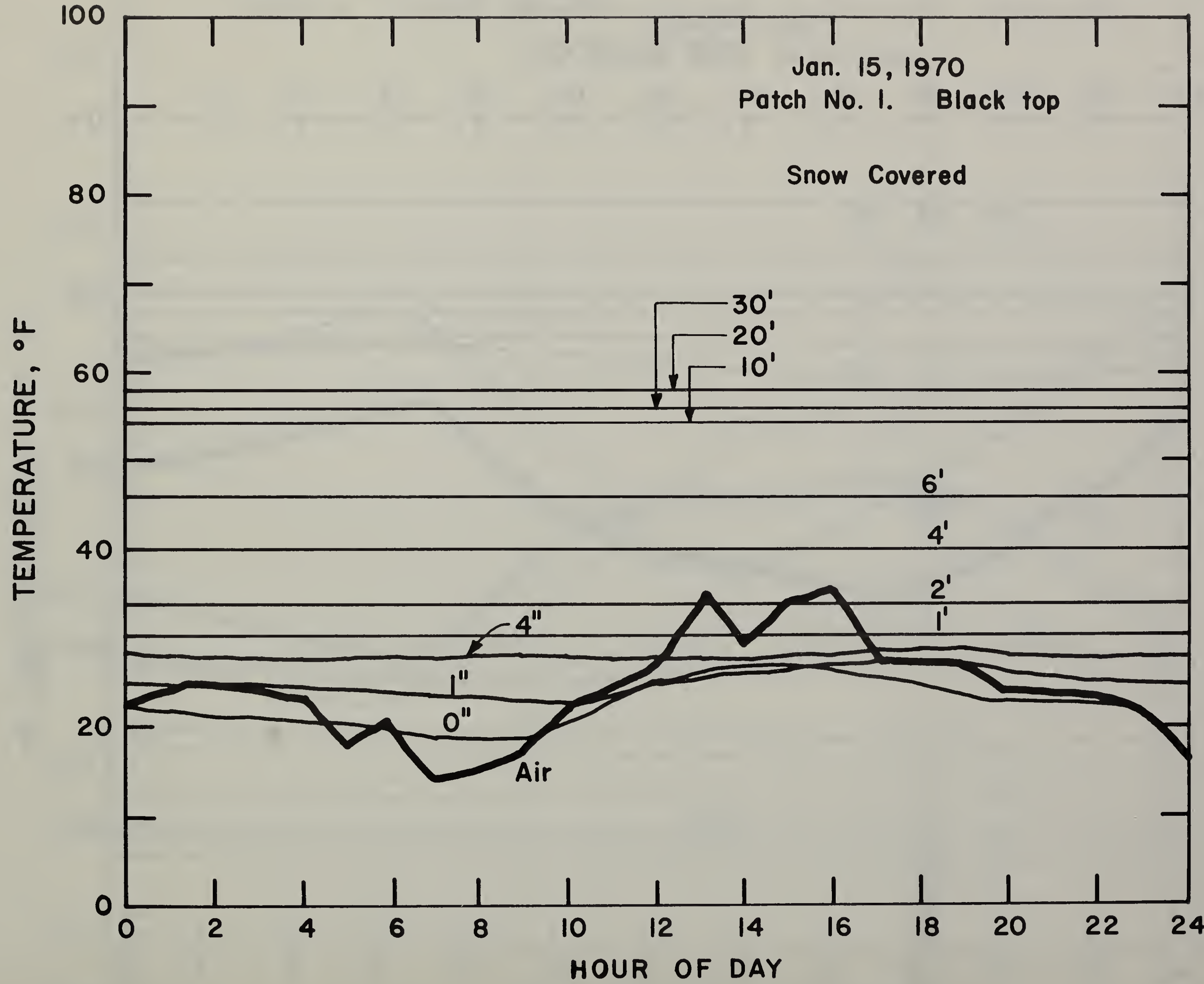


Figure 17 Diurnal Temperature Variation for Patch No. 1 (black surface) on December 9, 1969

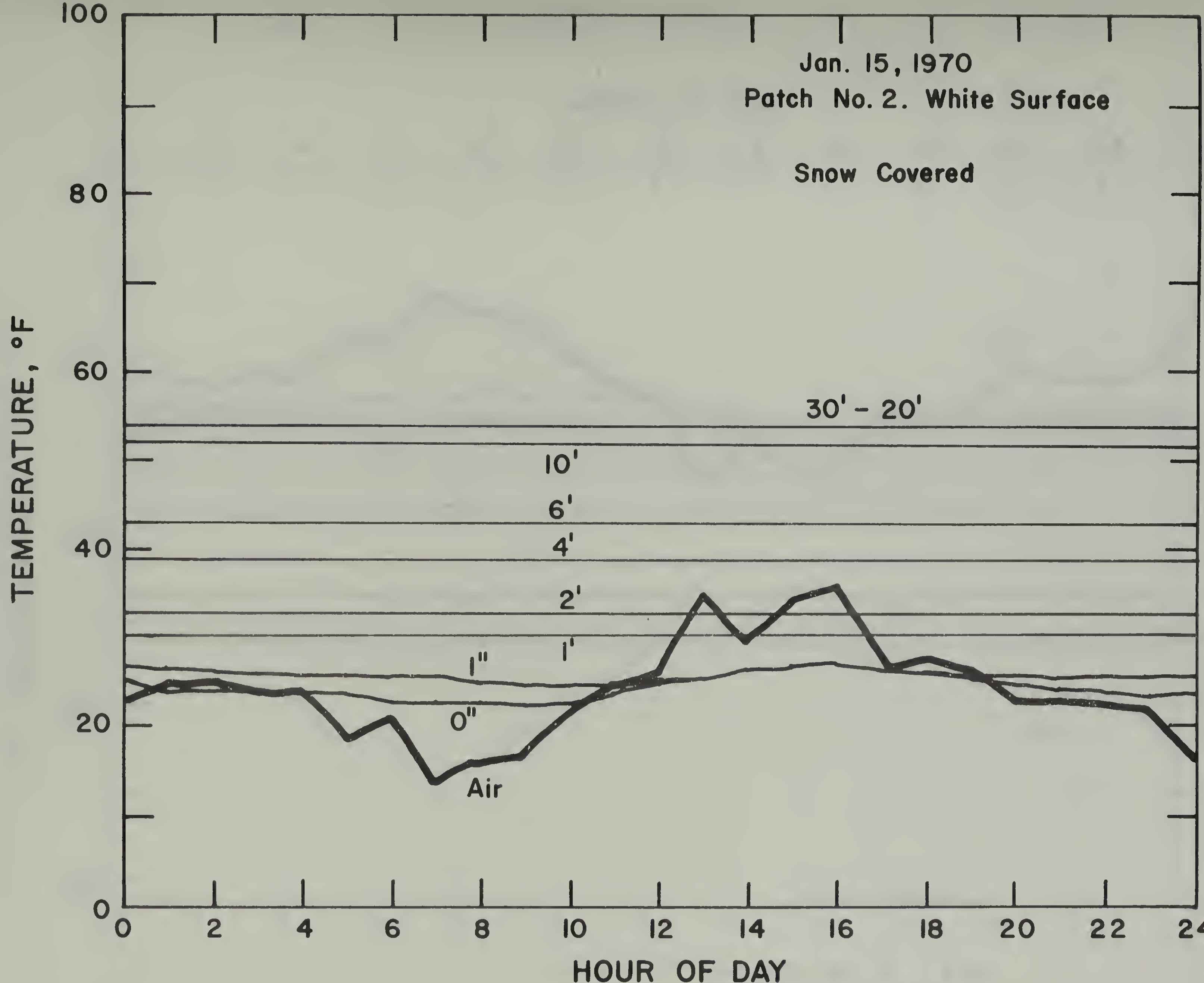


Figure 18 Diurnal Temperature Variation for Patch No. 2 (white surface) on December 9, 1969

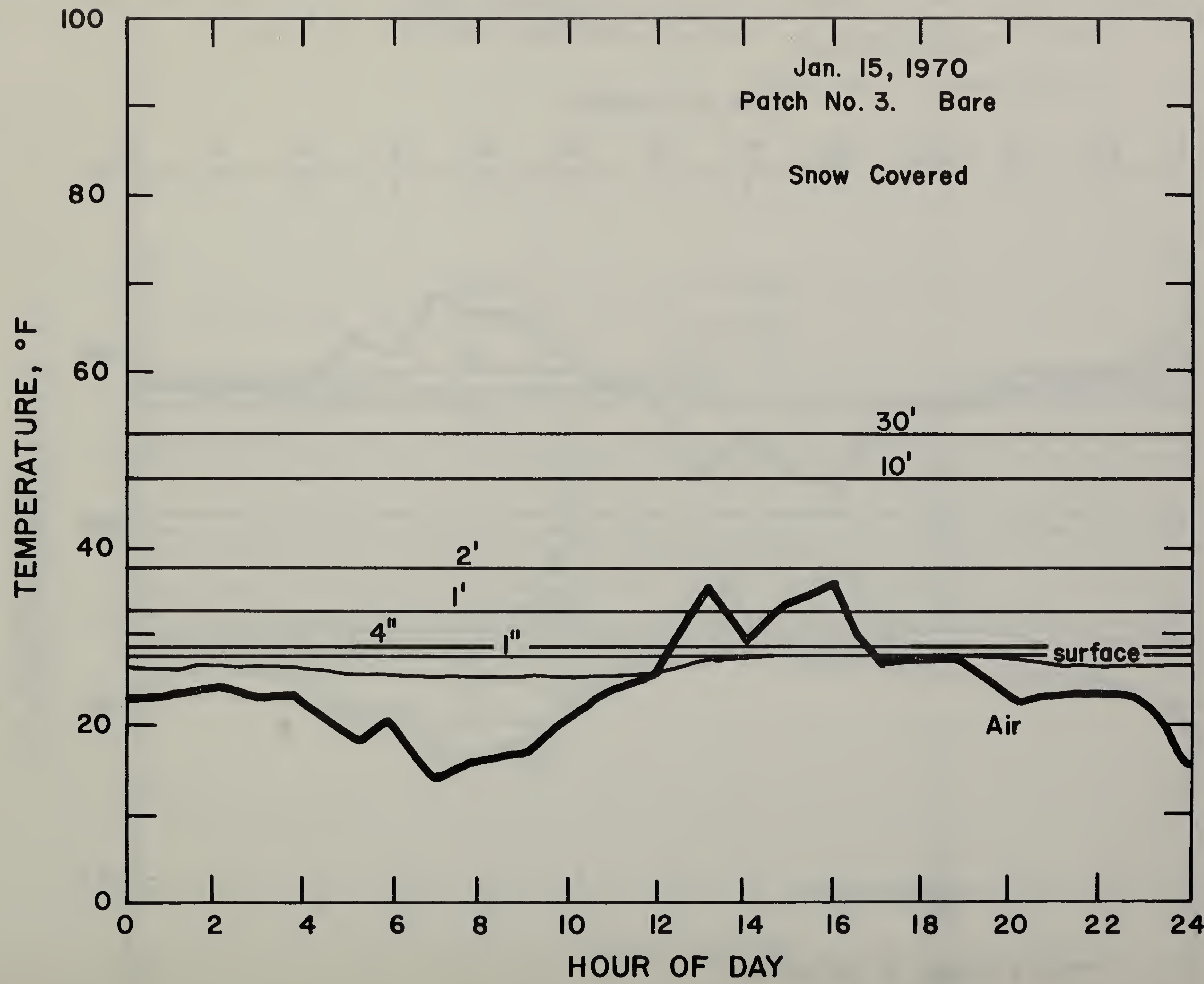


Figure 19 Diurnal Temperature Variation for Patch No. 3 (bare surface) on December 9, 1969

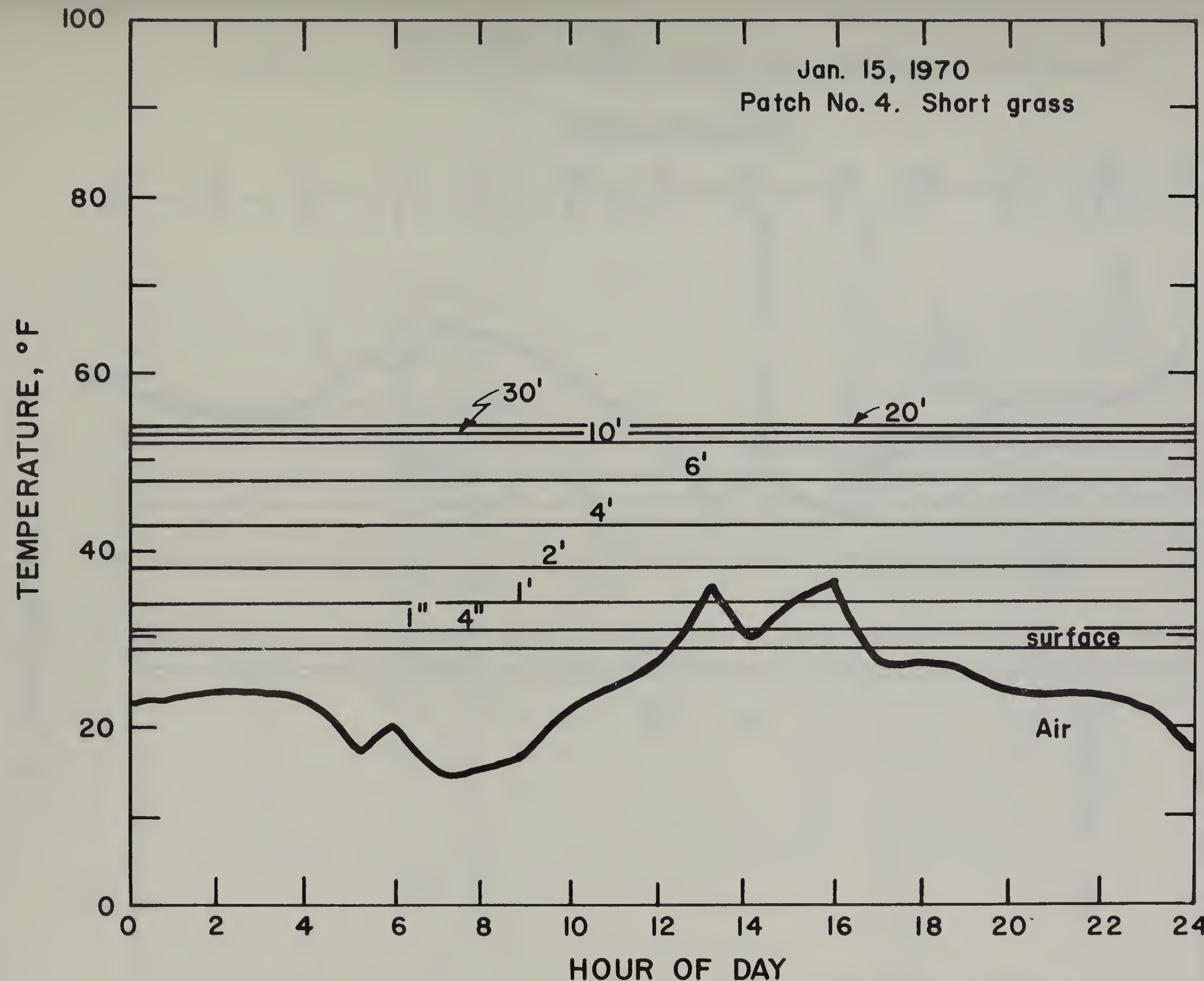


Figure 20 Diurnal Temperature Variation for Patch No. 4 (short grass) on December 9, 1969

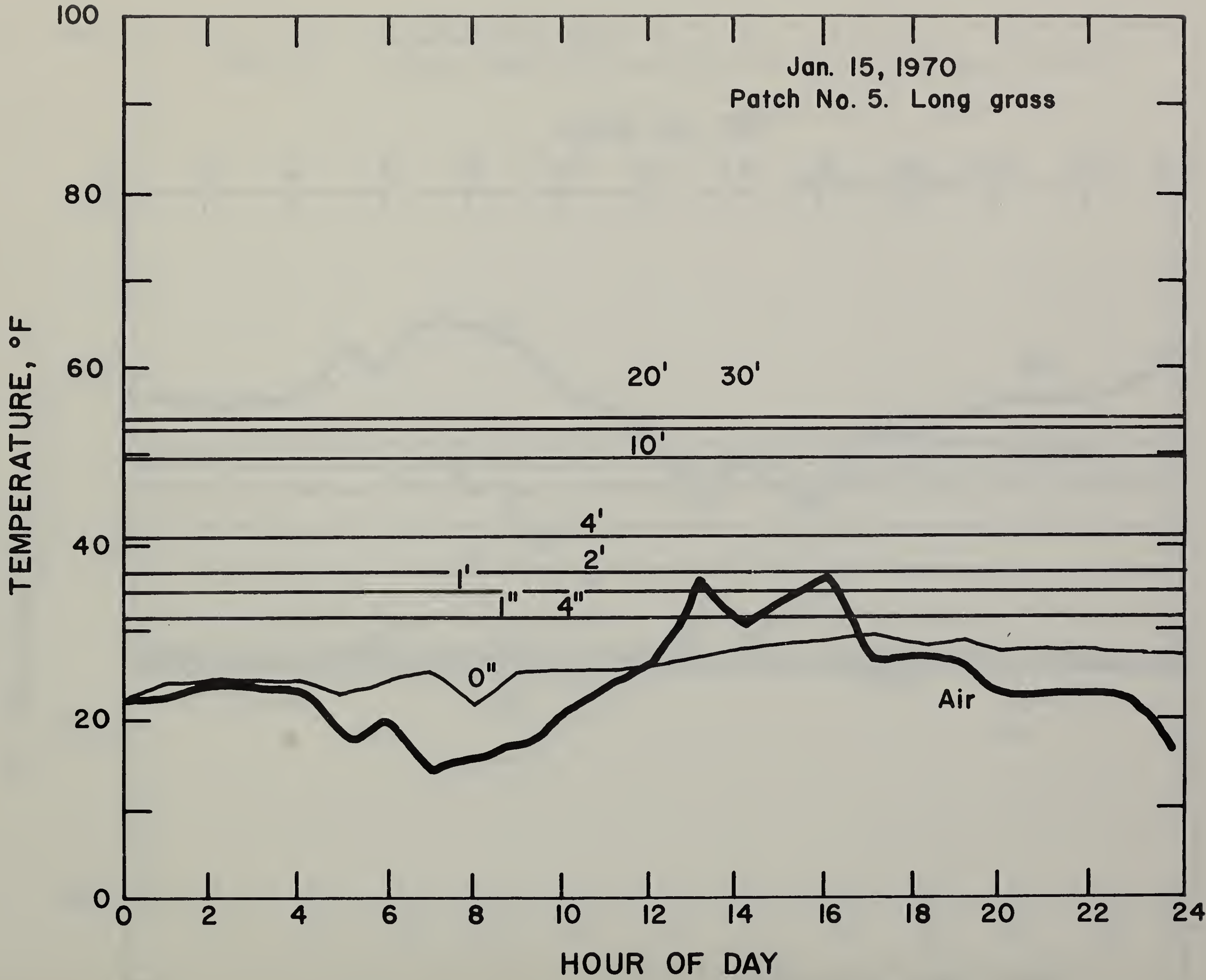
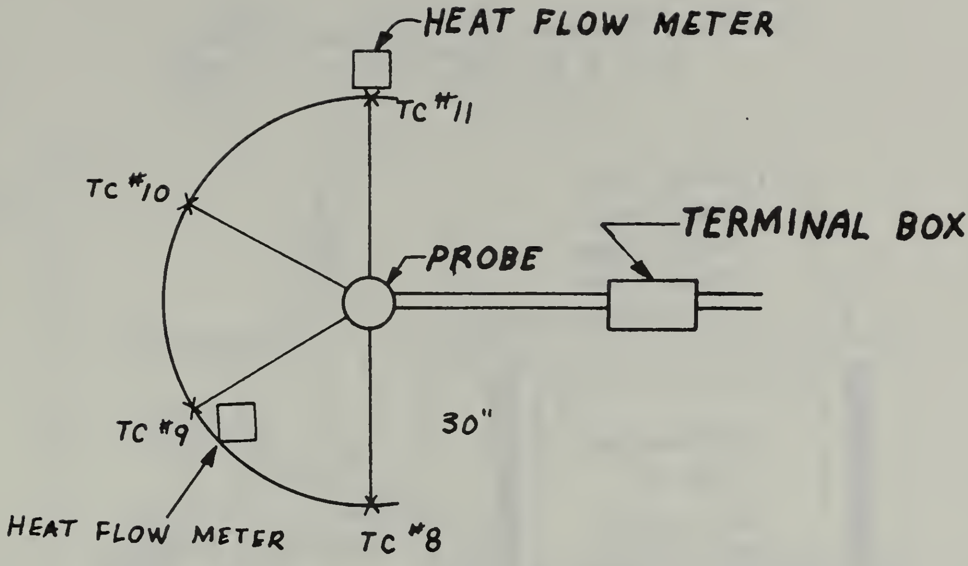


Figure 21 Diurnal Temperature Variation for Patch No. 5 (long grass) on December 9, 1969



TC #11 - 1" BELOW SURFACE
TC #10 - 2" " "
TC #9 - 4" " "
TC #8 - 12" " "

PATCH #1 AND 2

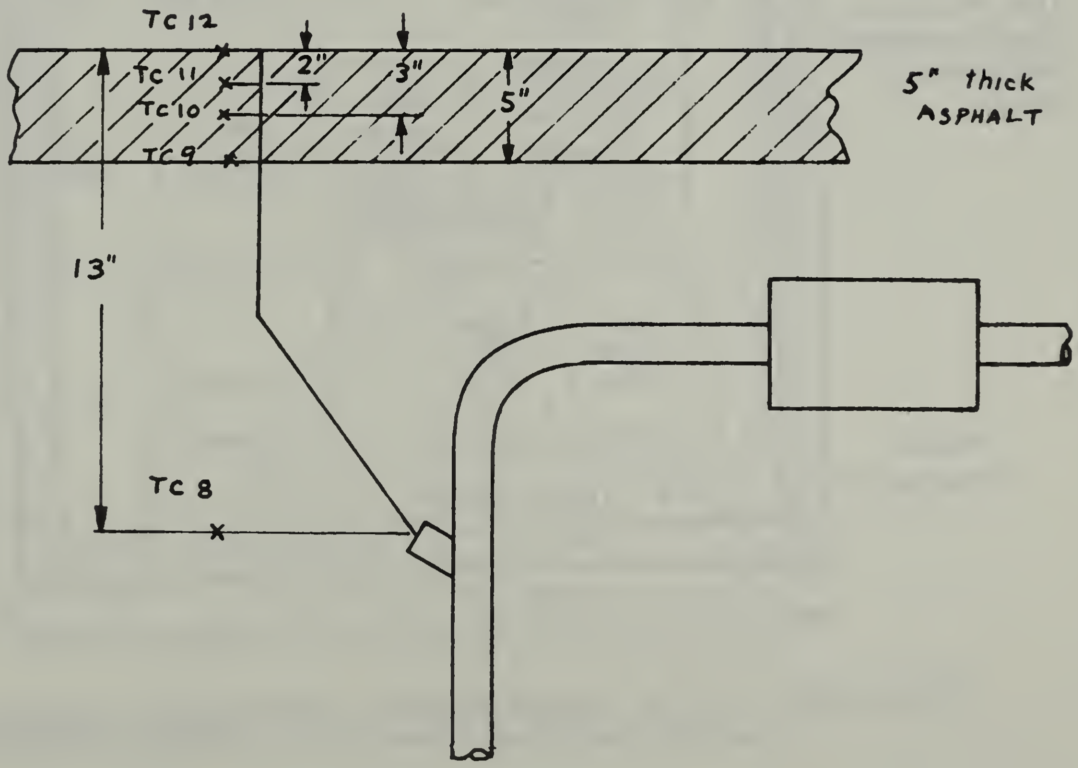


Figure 22 Thermocouple Installation Near the Surface

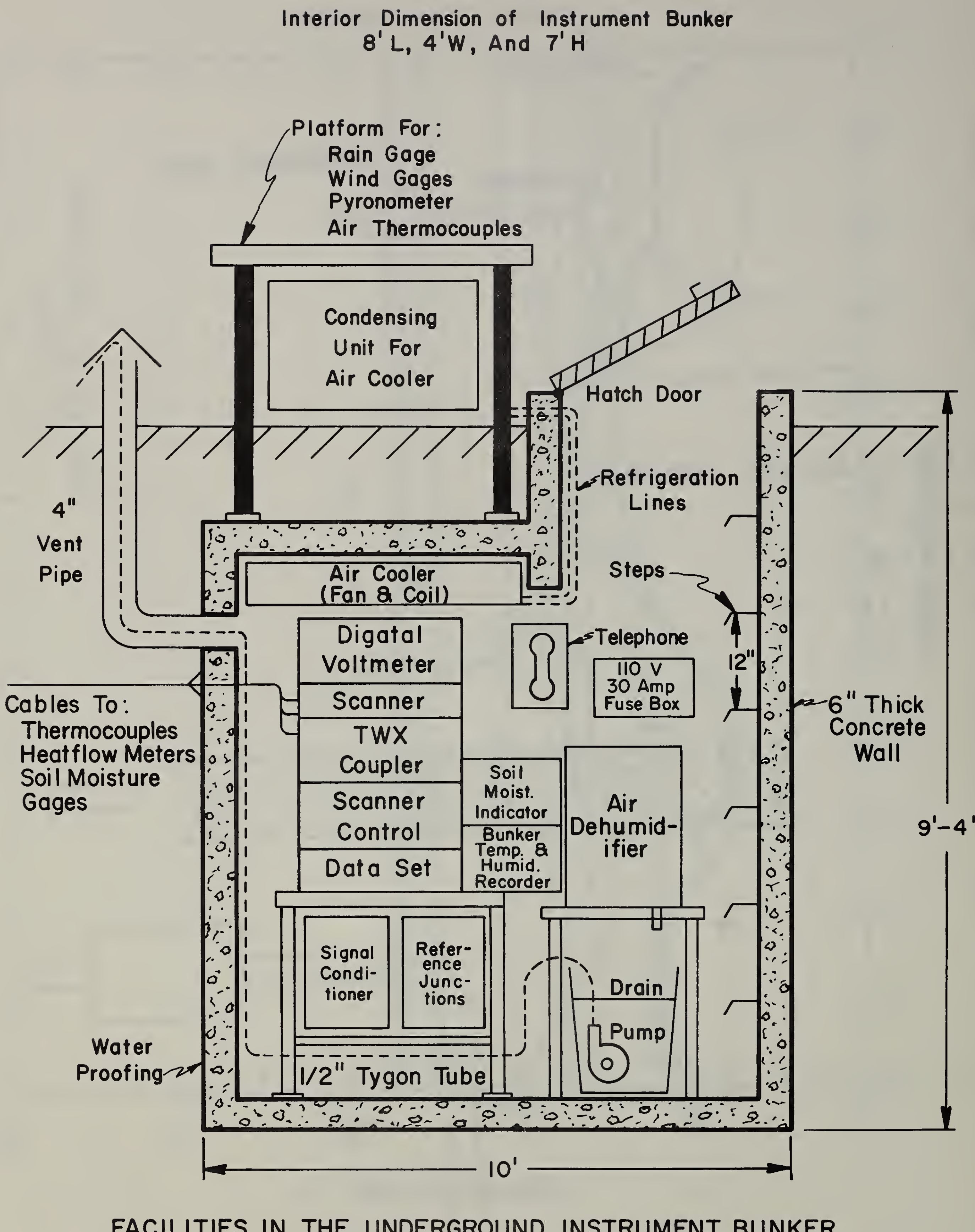
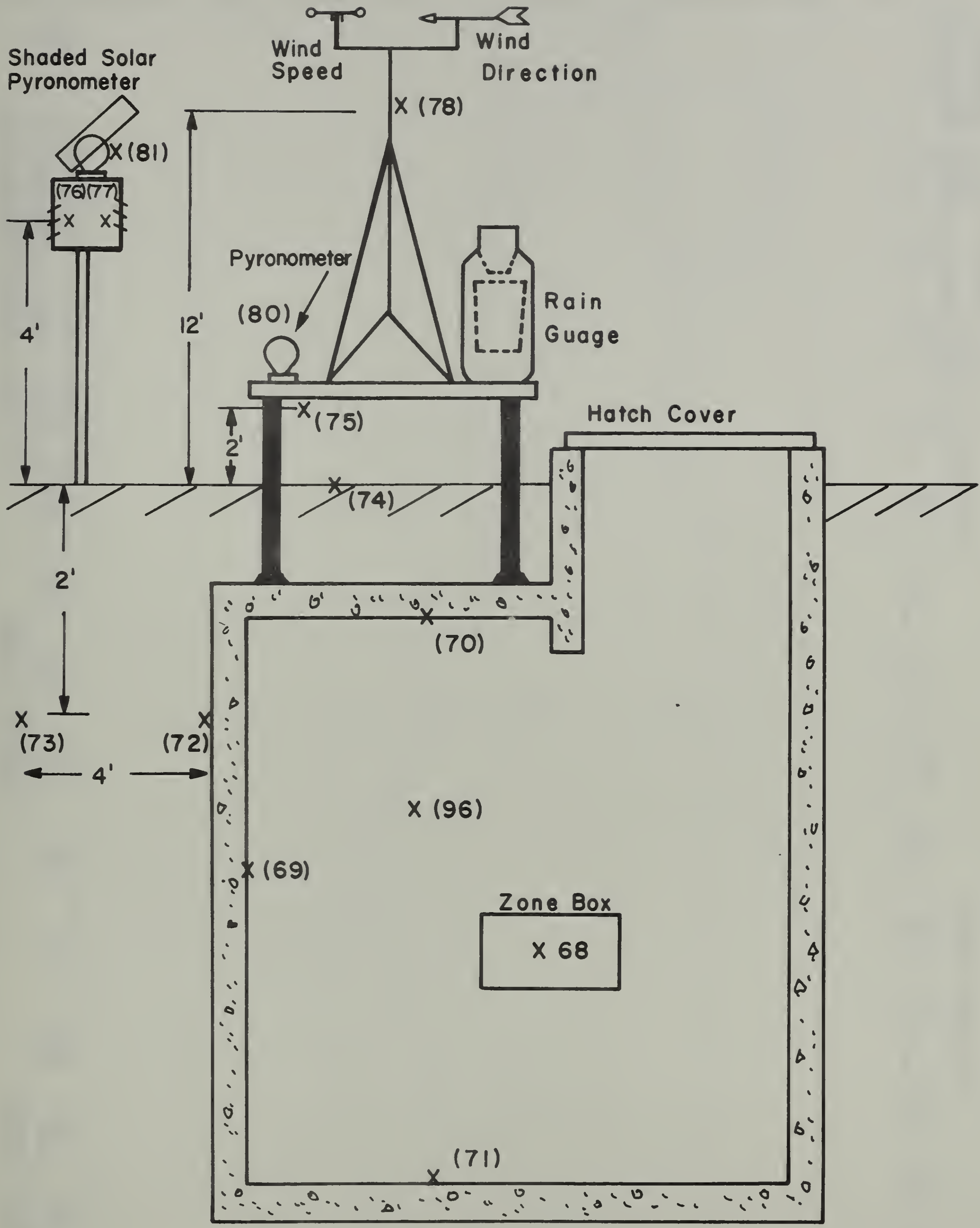


Figure 23A Facilities in the Underground Instrumentation Bunker and Thermocouple Location in and Around the Bunker



X Thermocouple Locations in and around Instrument Bunker

Figure 23B Facilities in the Underground Instrumentation Bunker and Thermocouple Location in and Around the Bunker

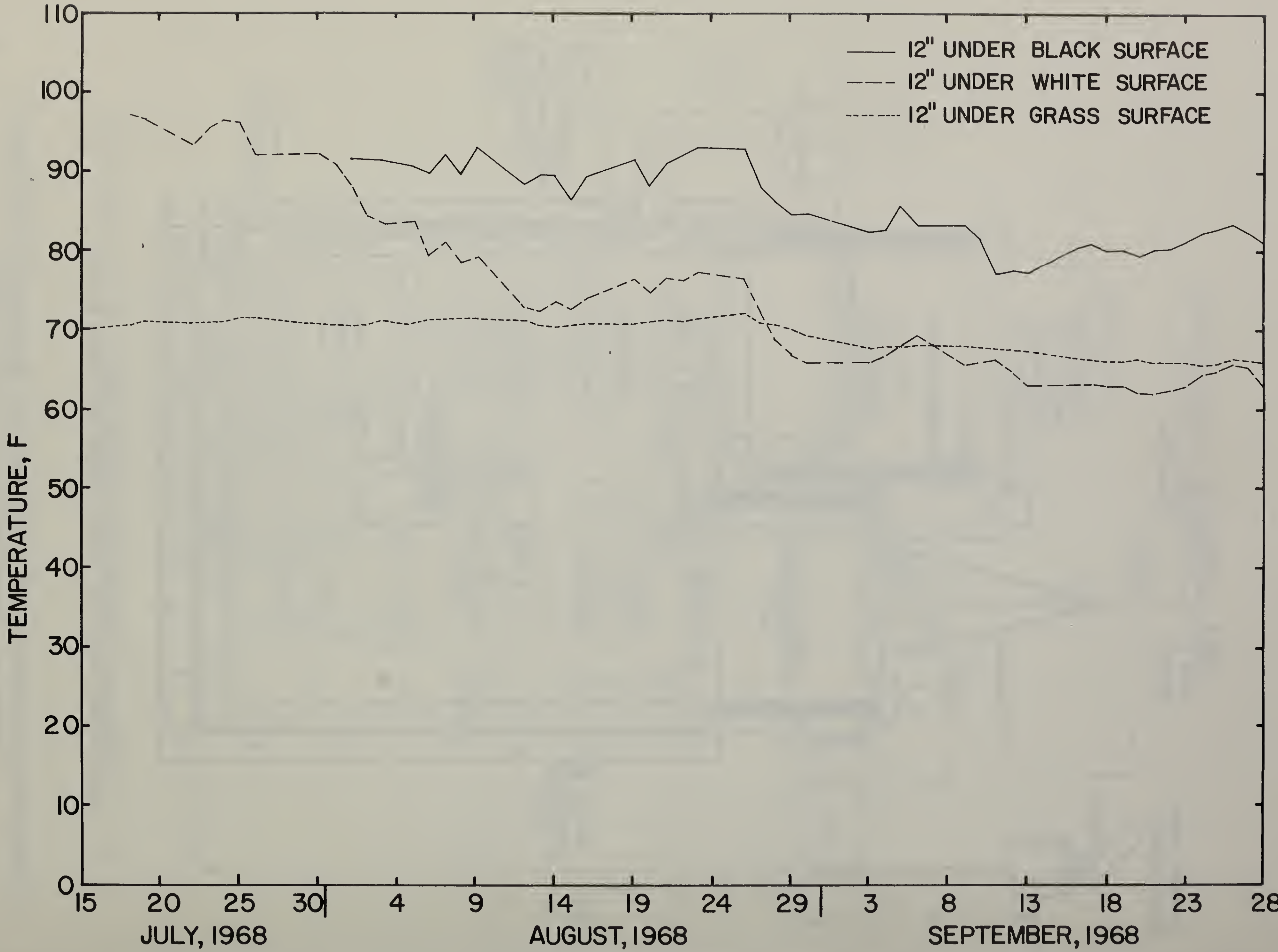


Figure 24A Earth Temperature Records Under Black, White and Grass Covered Surfaces

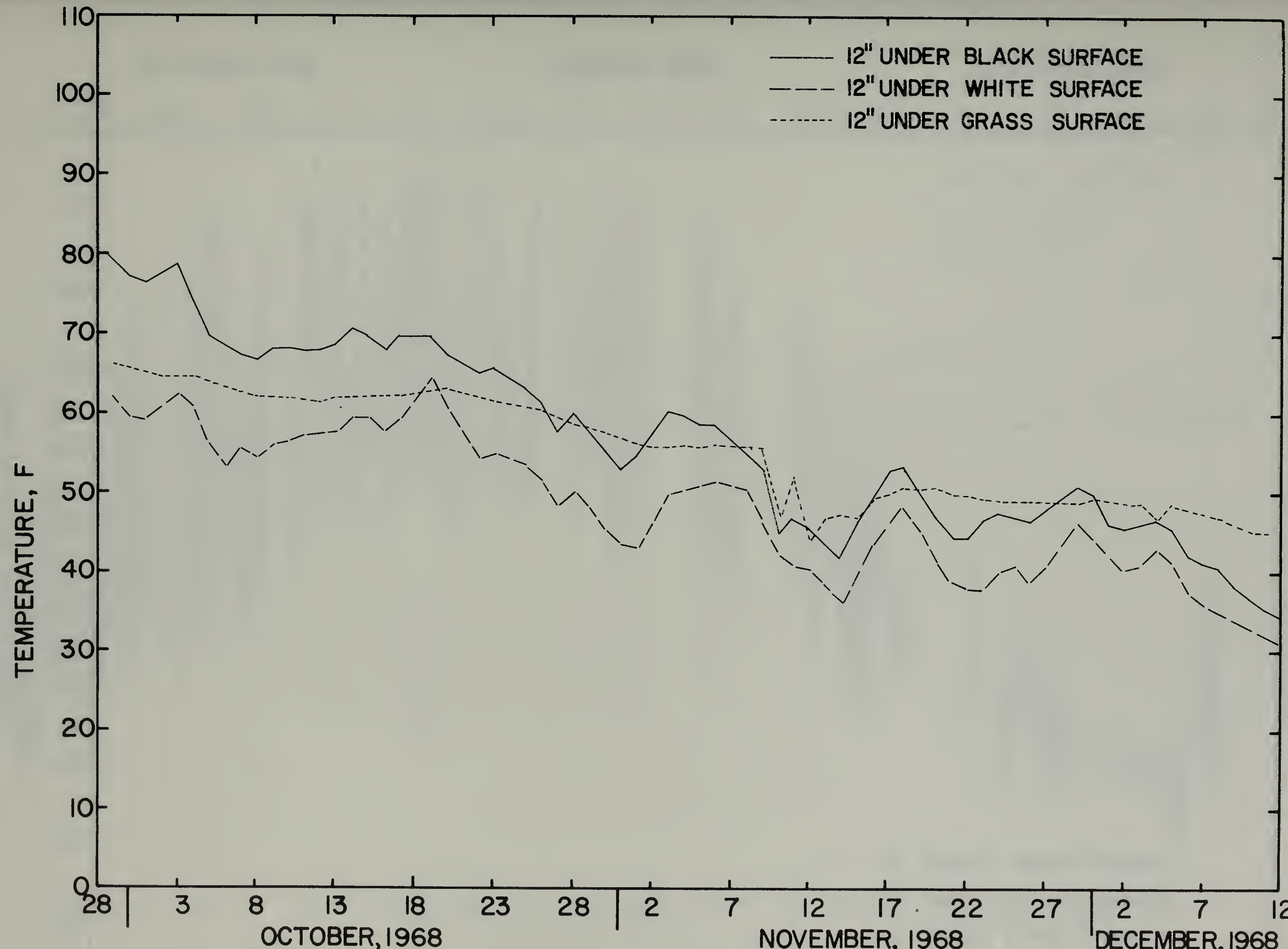


Figure 24B Earth Temperature Records Under Black, White and Grass Covered Surfaces

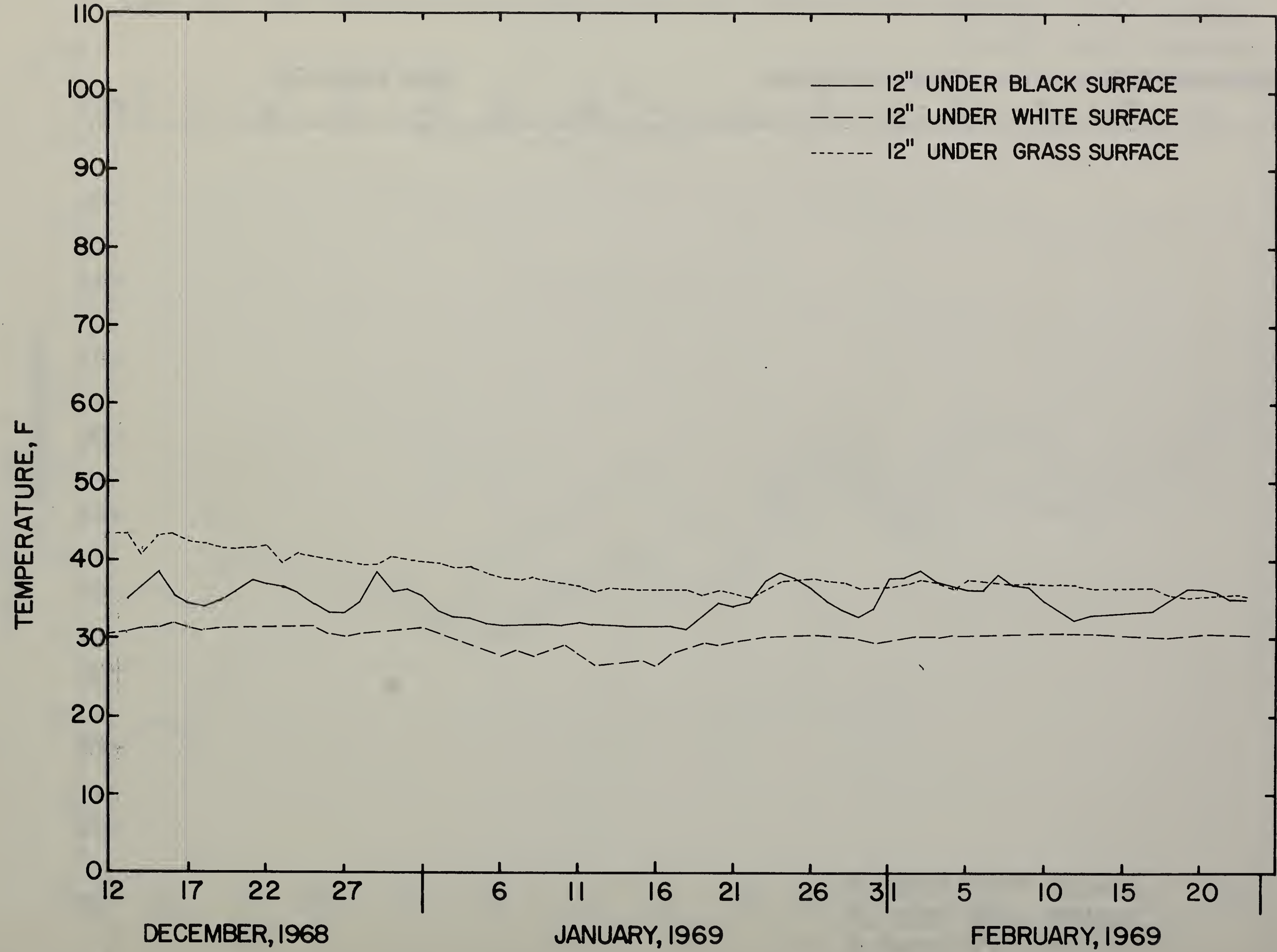


Figure 24C Earth Temperature Records Under Black, White and Grass Covered Surfaces

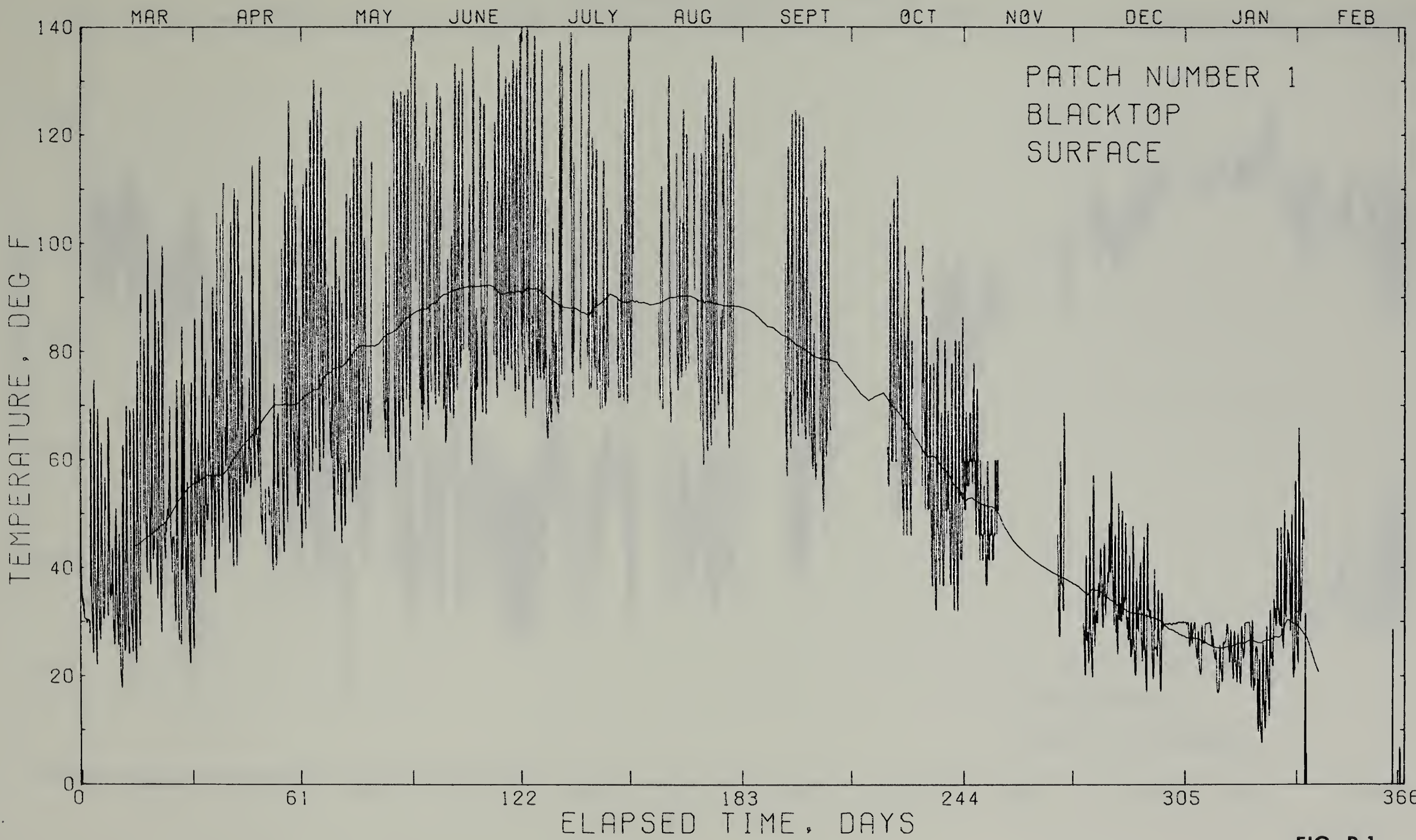

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 1
BLACKTOP
SURFACE
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-1

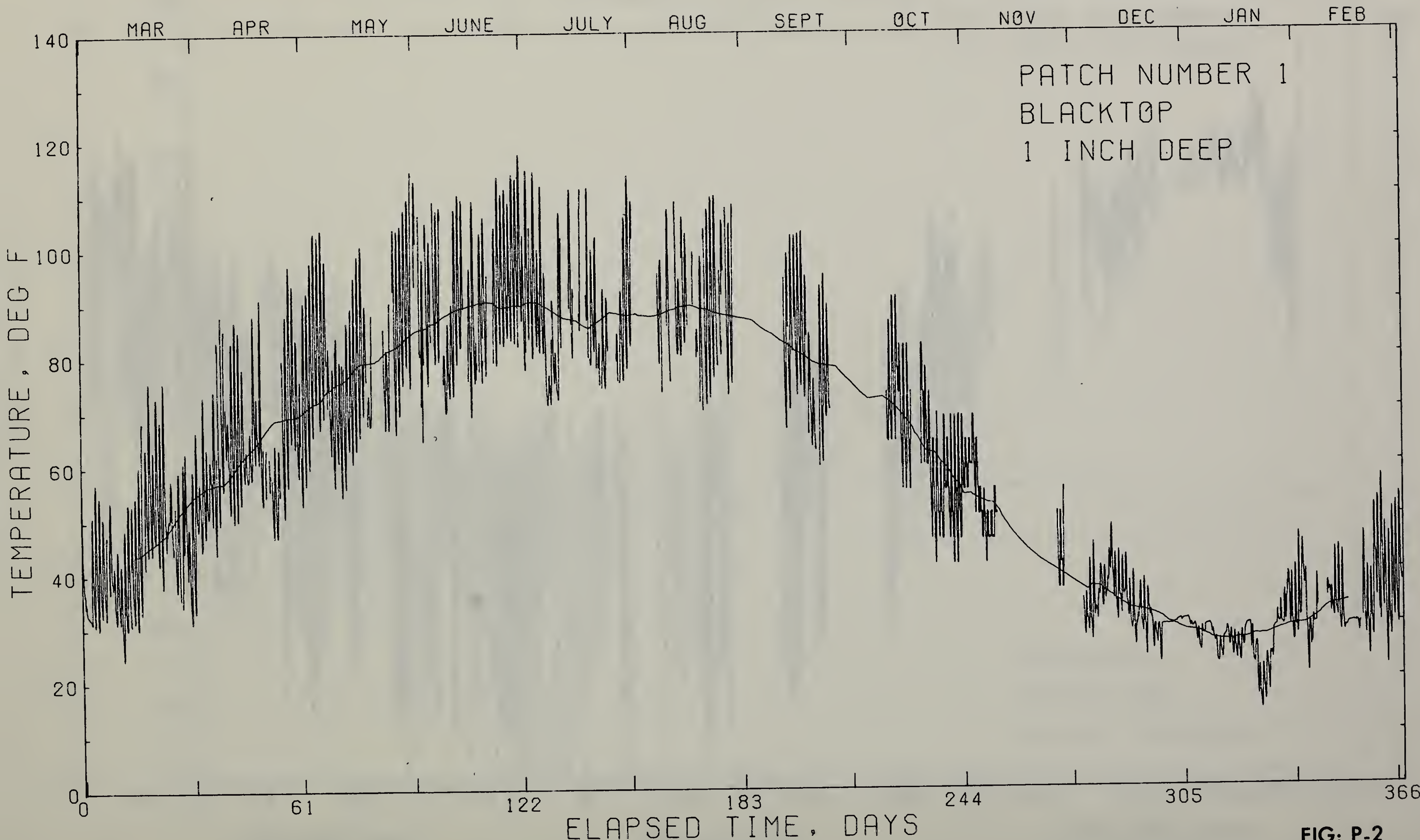

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 1
BLACKTOP
1 INCH DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG: P-2

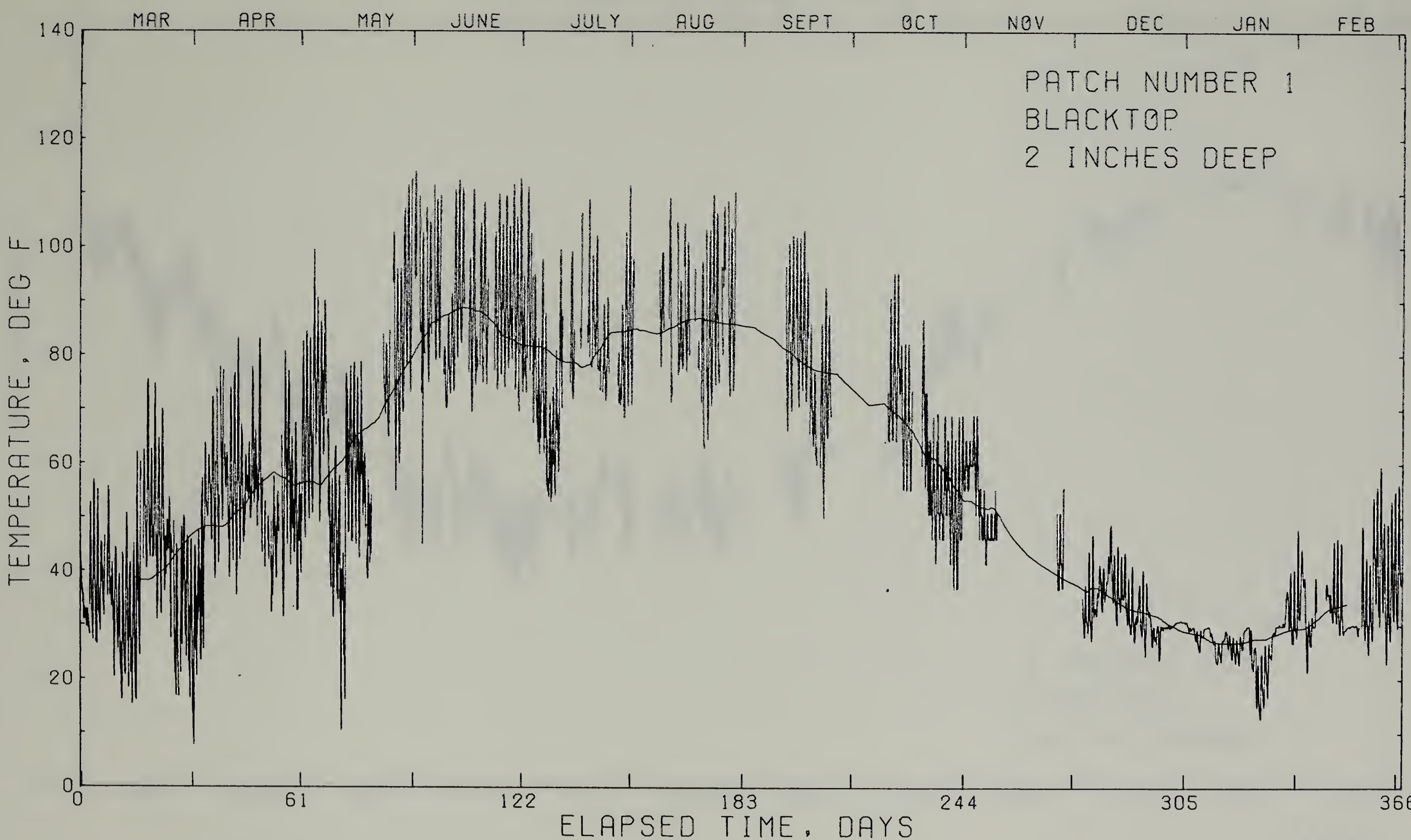

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 1
BLACKTOP
2 INCHES DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-3

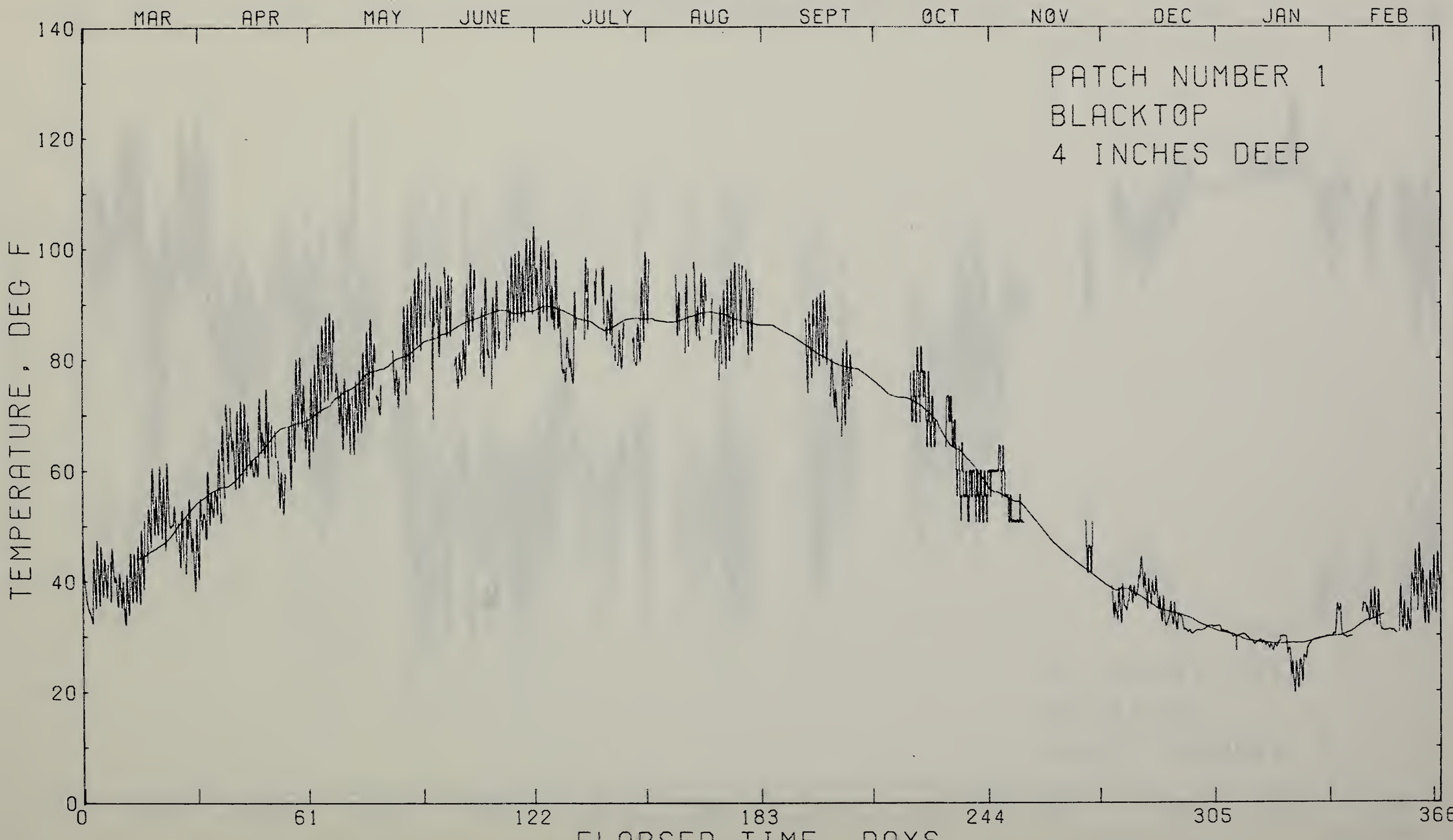

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 1
BLACKTOP
4 INCHES DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME DAYS

FIG. P-4

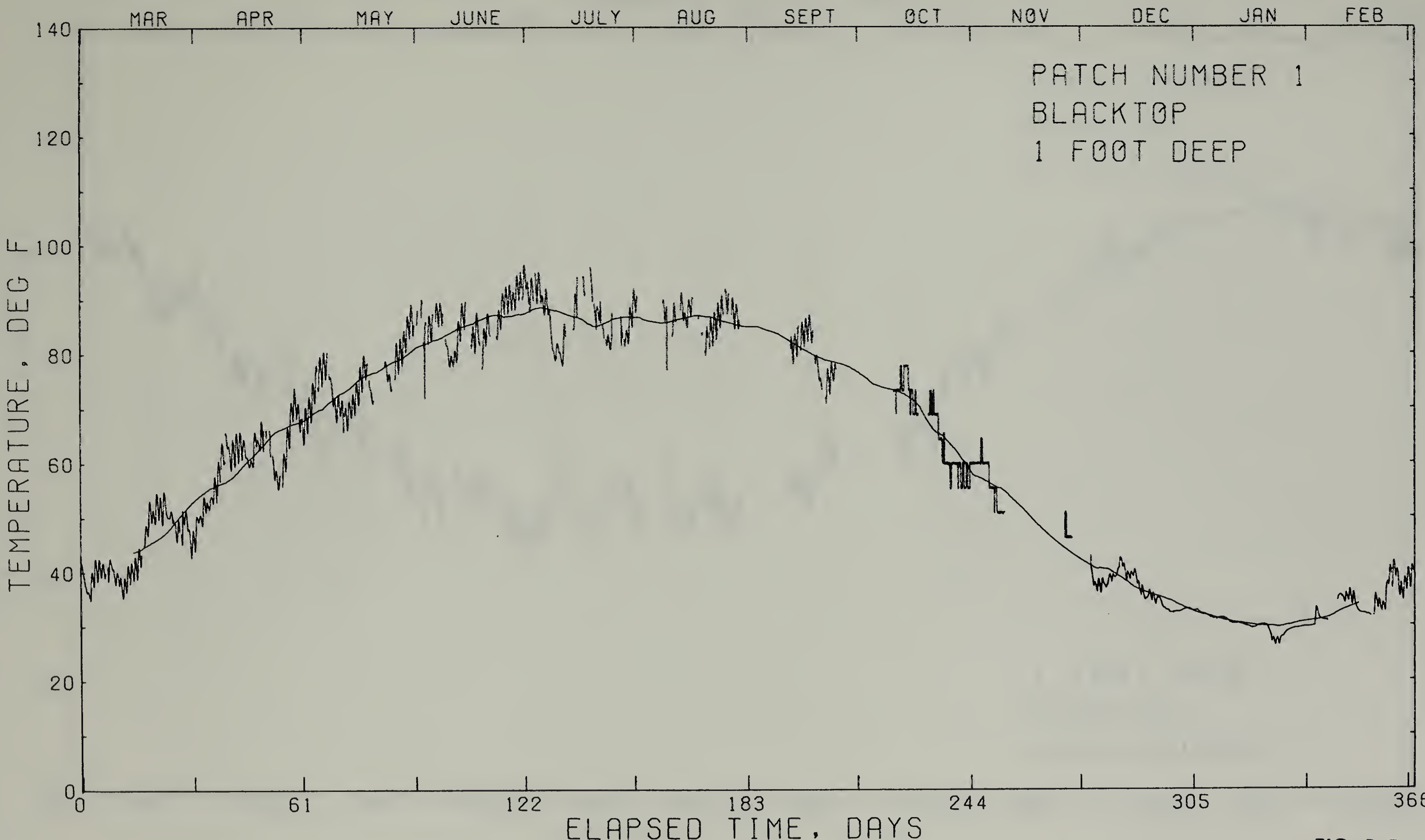

PATCH NUMBER 1
BLACKTOP
1 FOOT DEEP
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-5

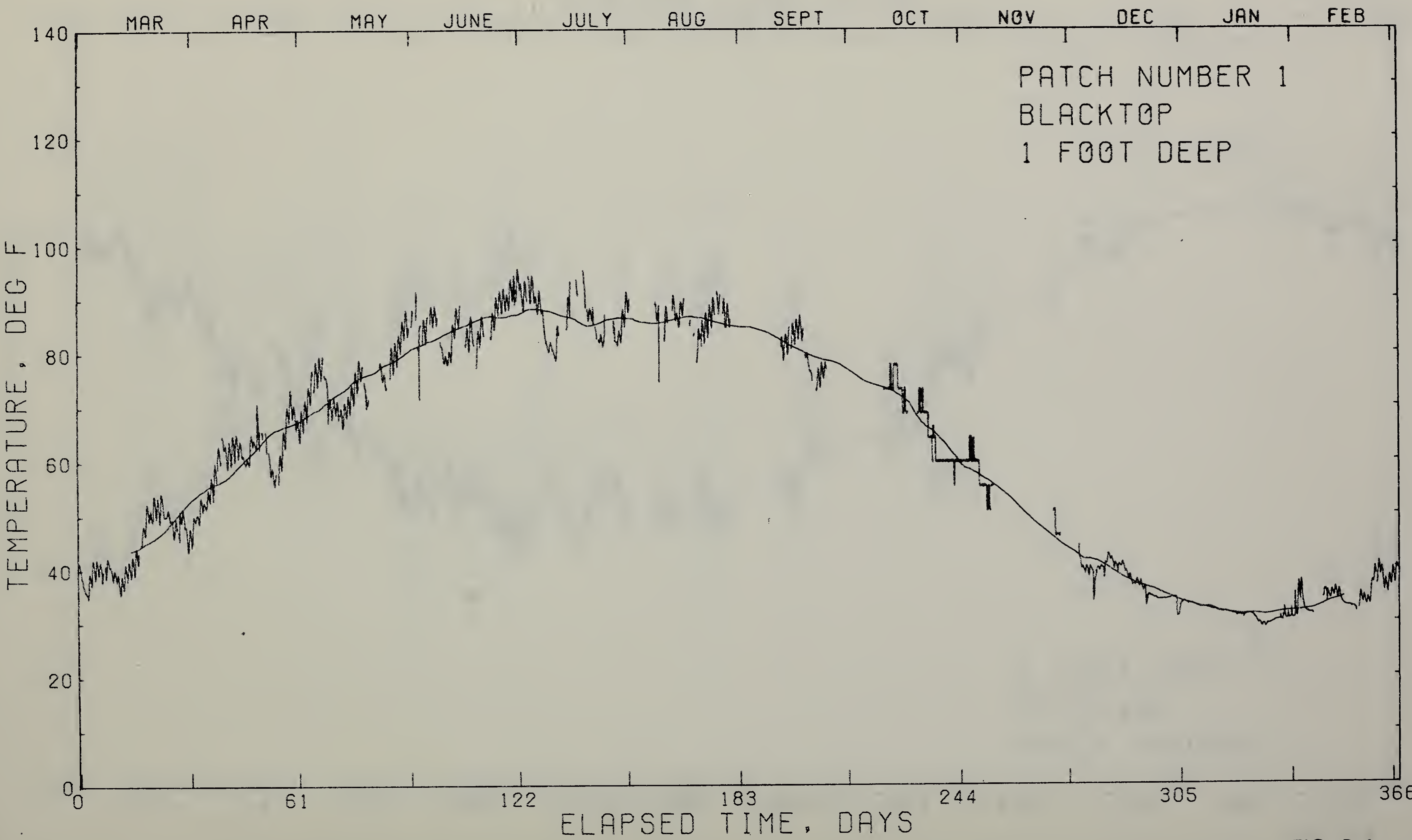

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 1
BLACKTOP
1 FOOT DEEP
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-6

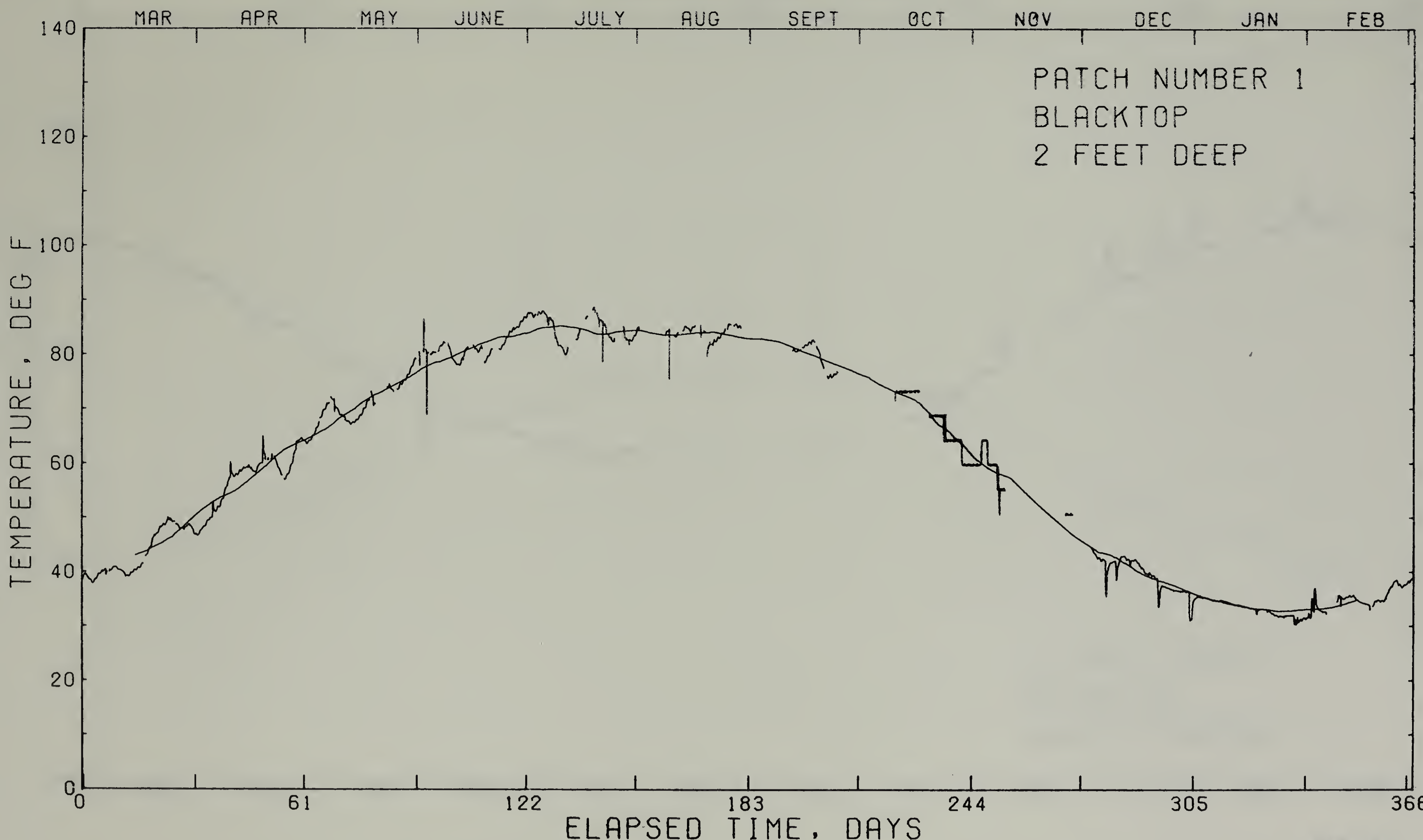

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 1
BLACKTOP
2 FEET DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-7

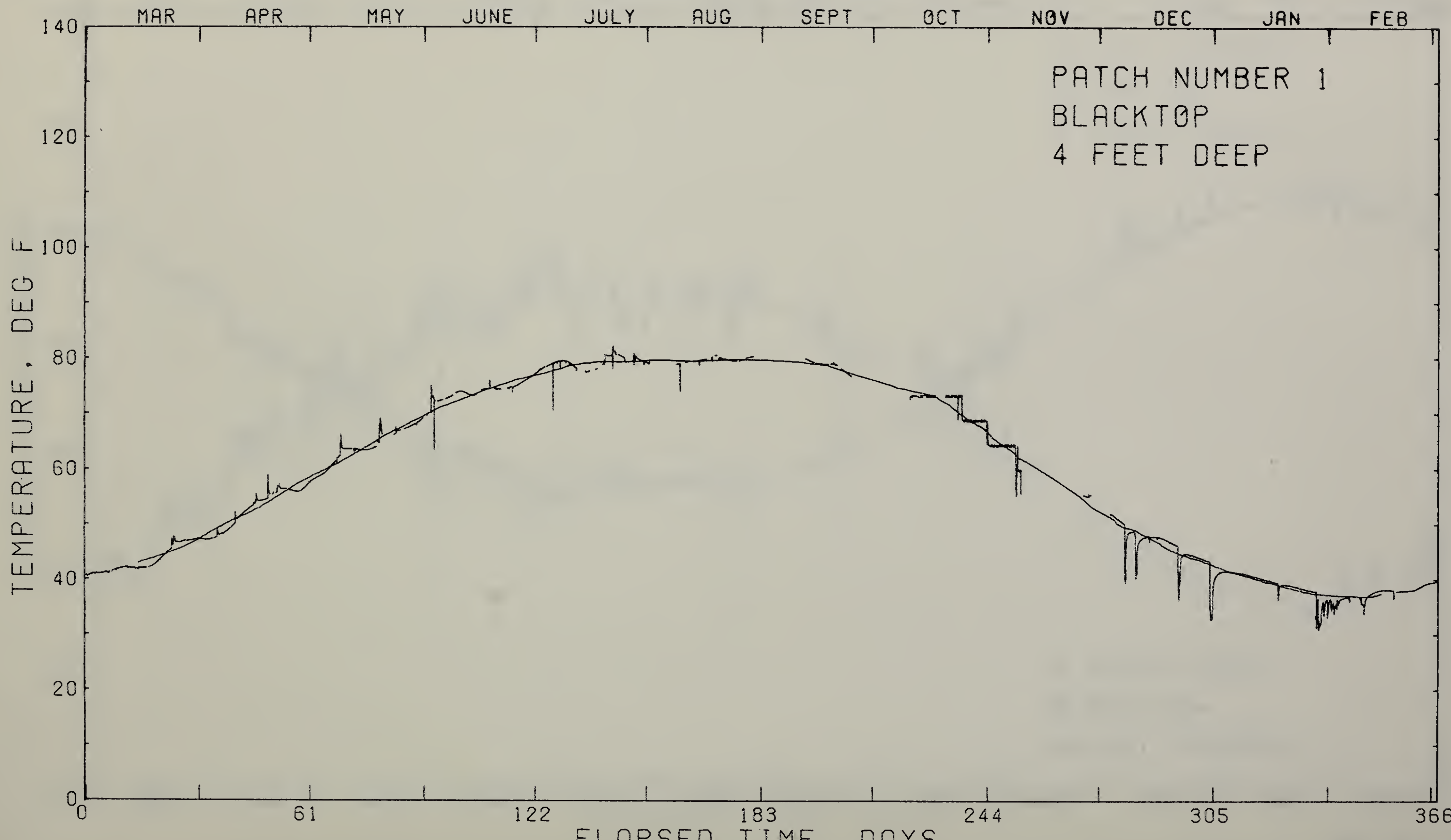

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 1
BLACKTOP
4 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-8

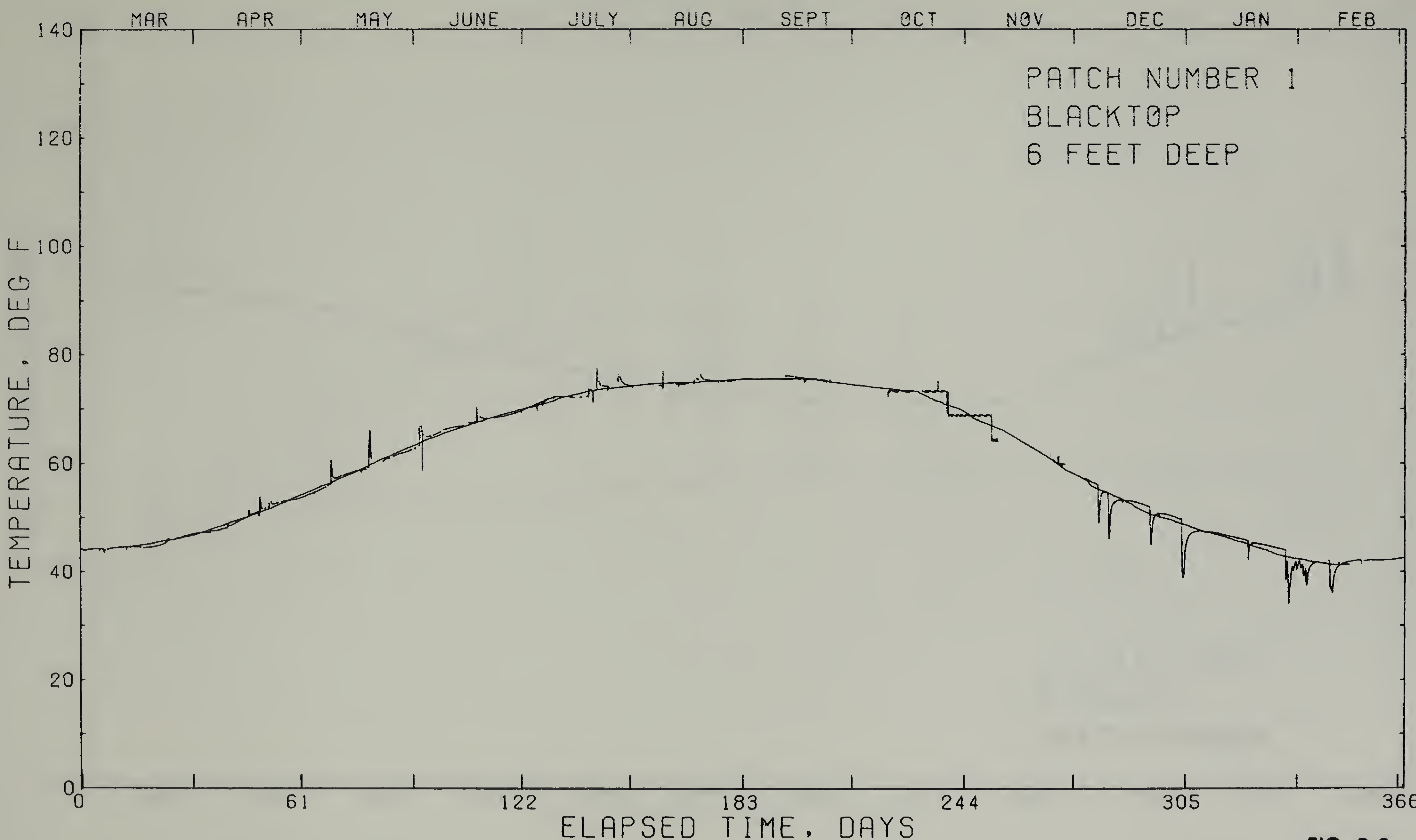

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 1
BLACKTOP
6 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-9

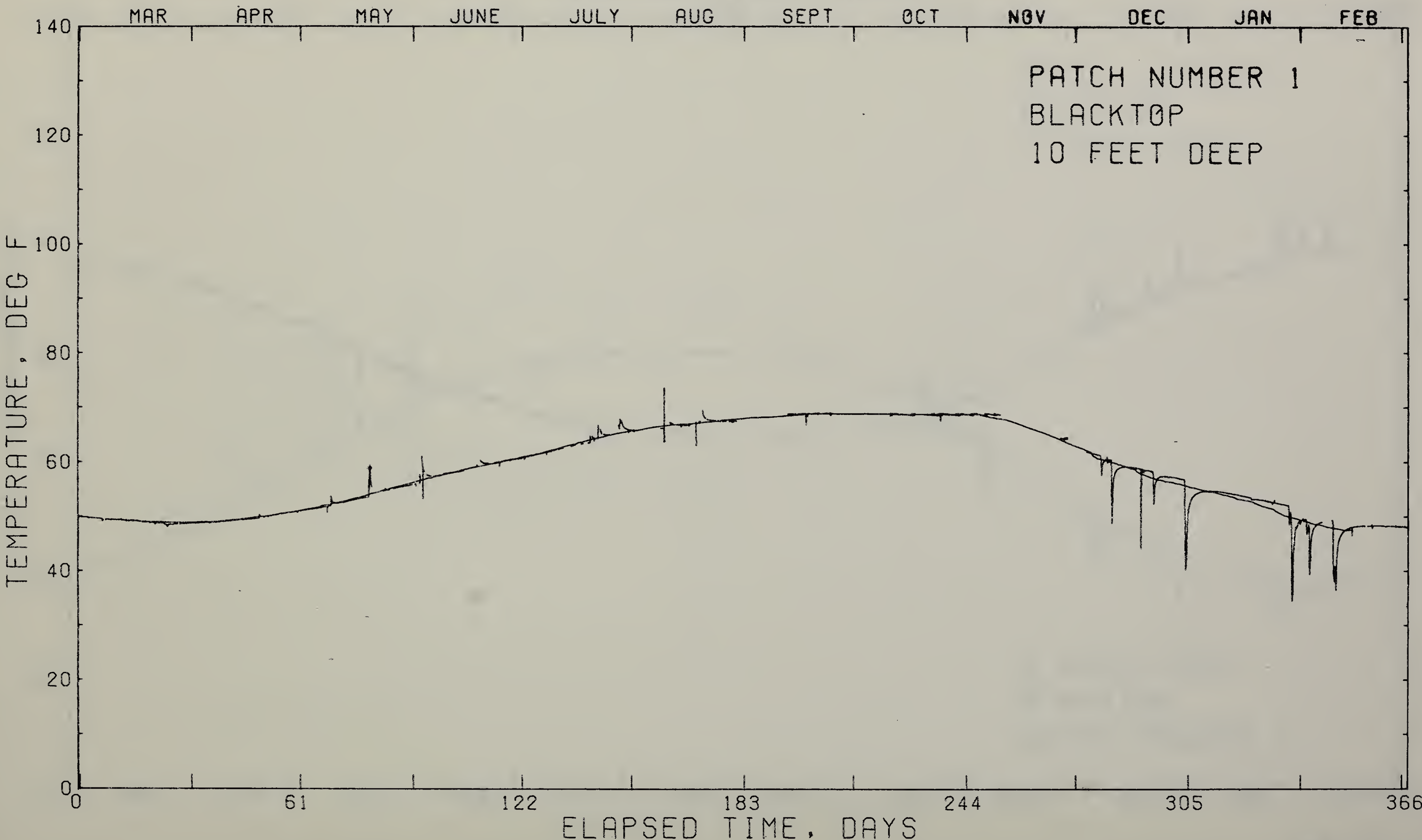

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 1
BLACKTOP
10 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-10

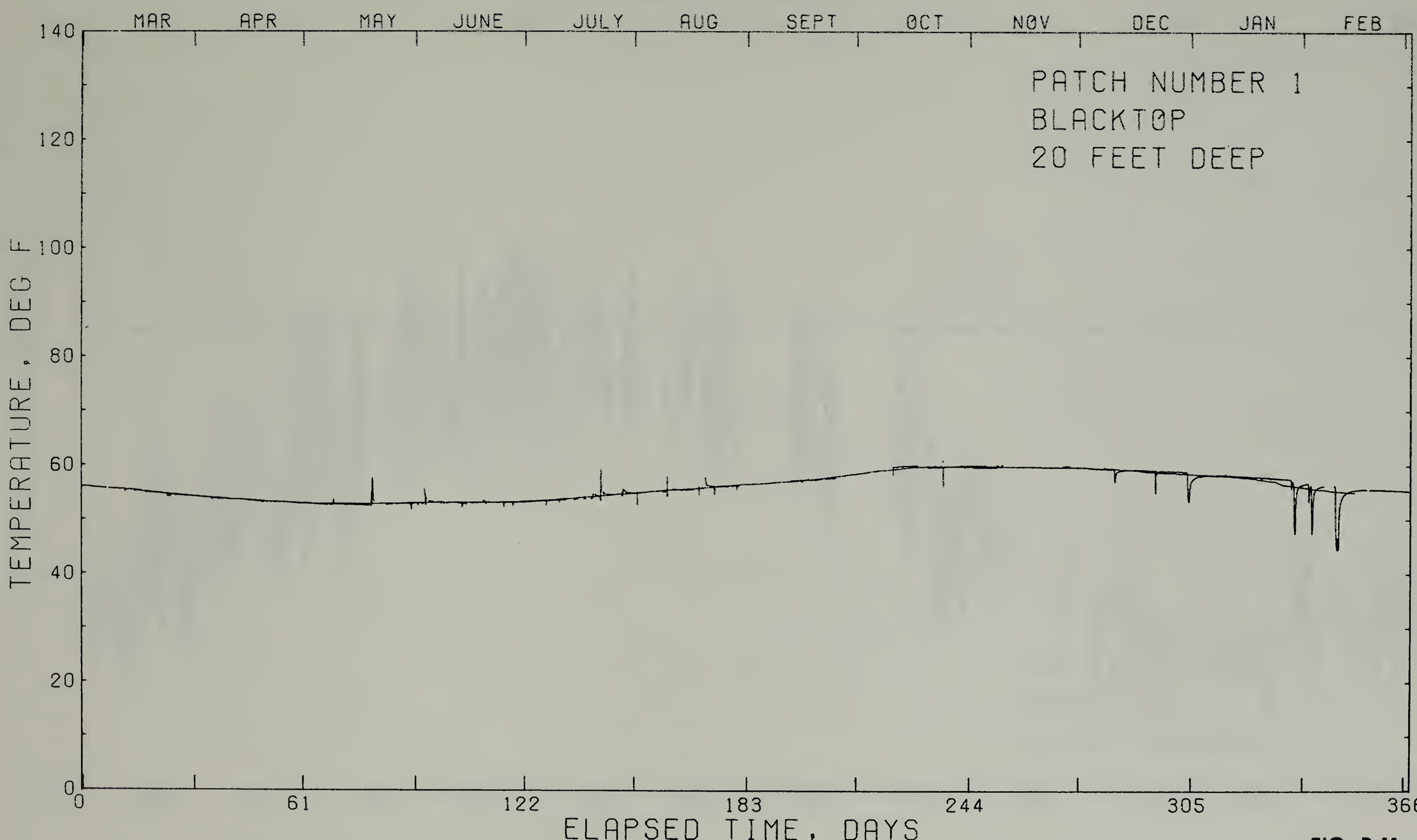

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 1
BLACKTOP
20 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-11

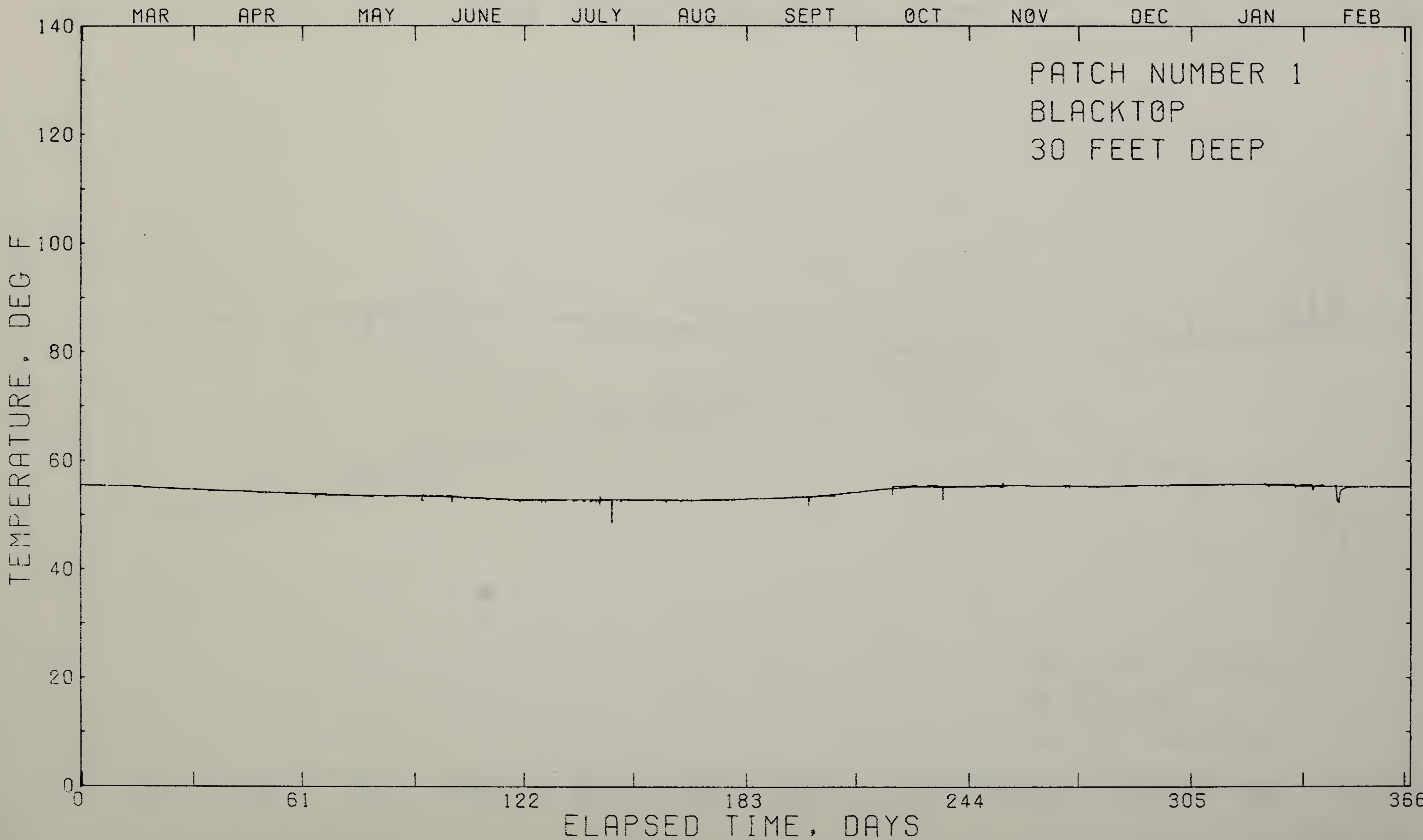
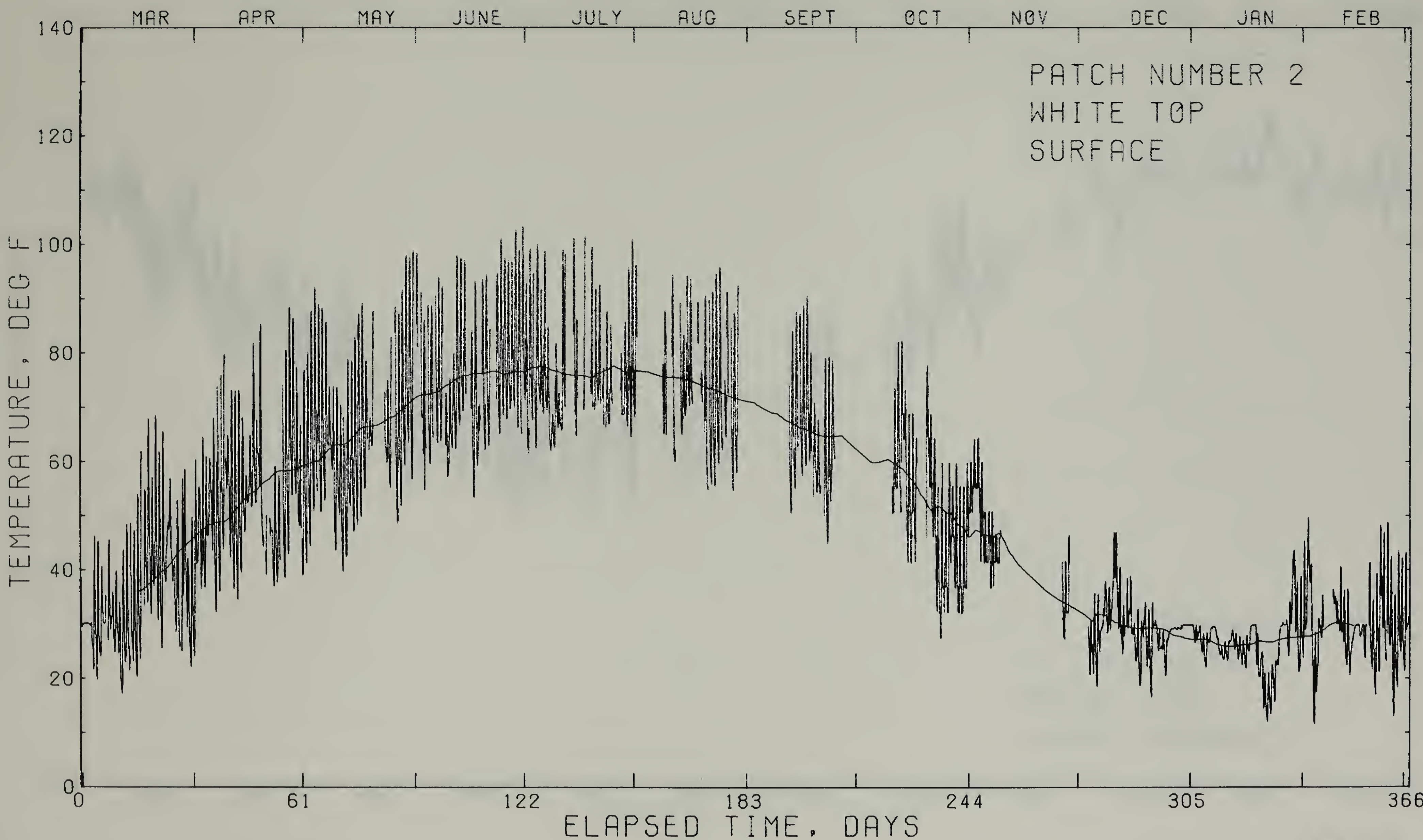
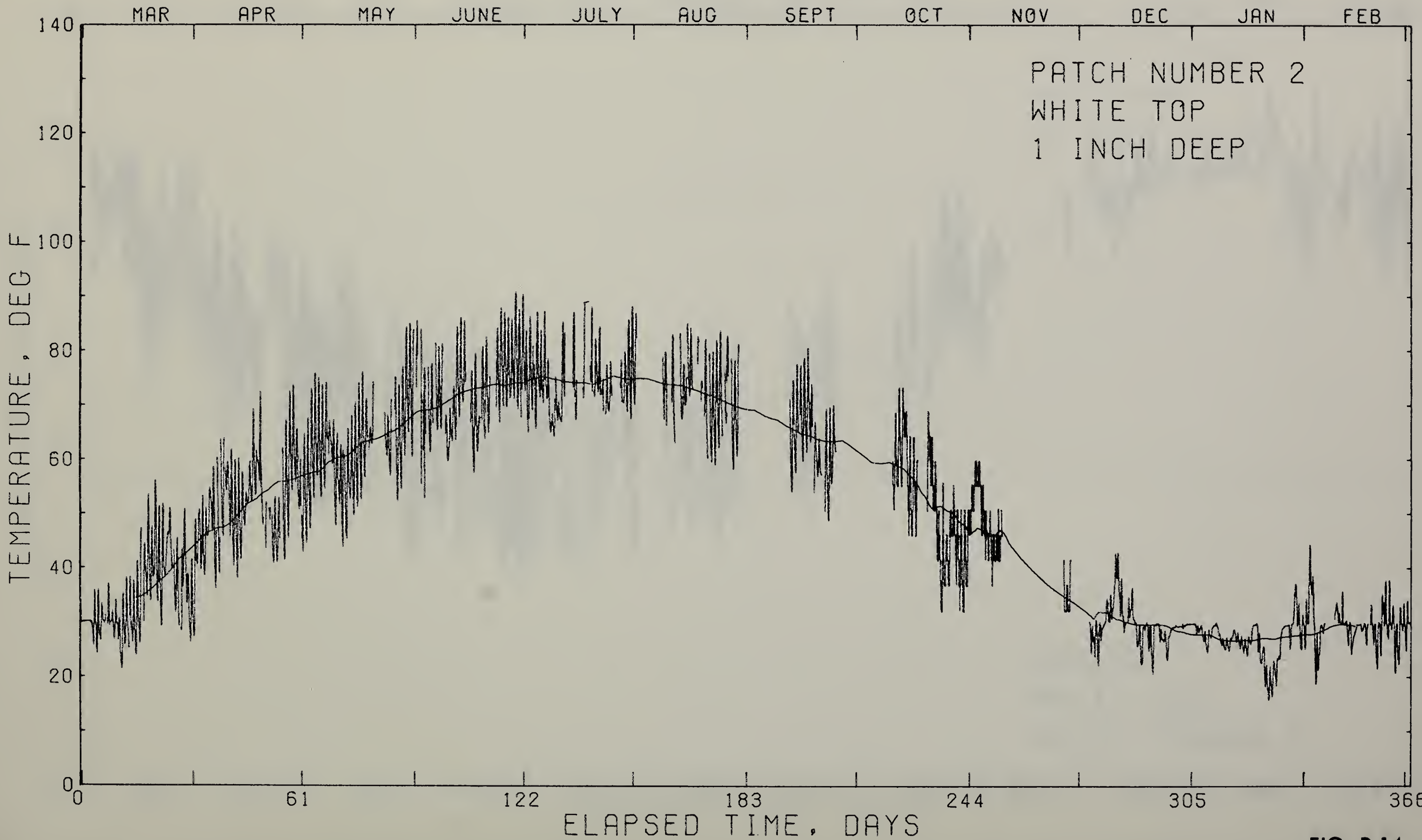

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 1
BLACKTOP
30 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-12



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TOP
SURFACE
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-13



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TOP
1 INCH DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-14

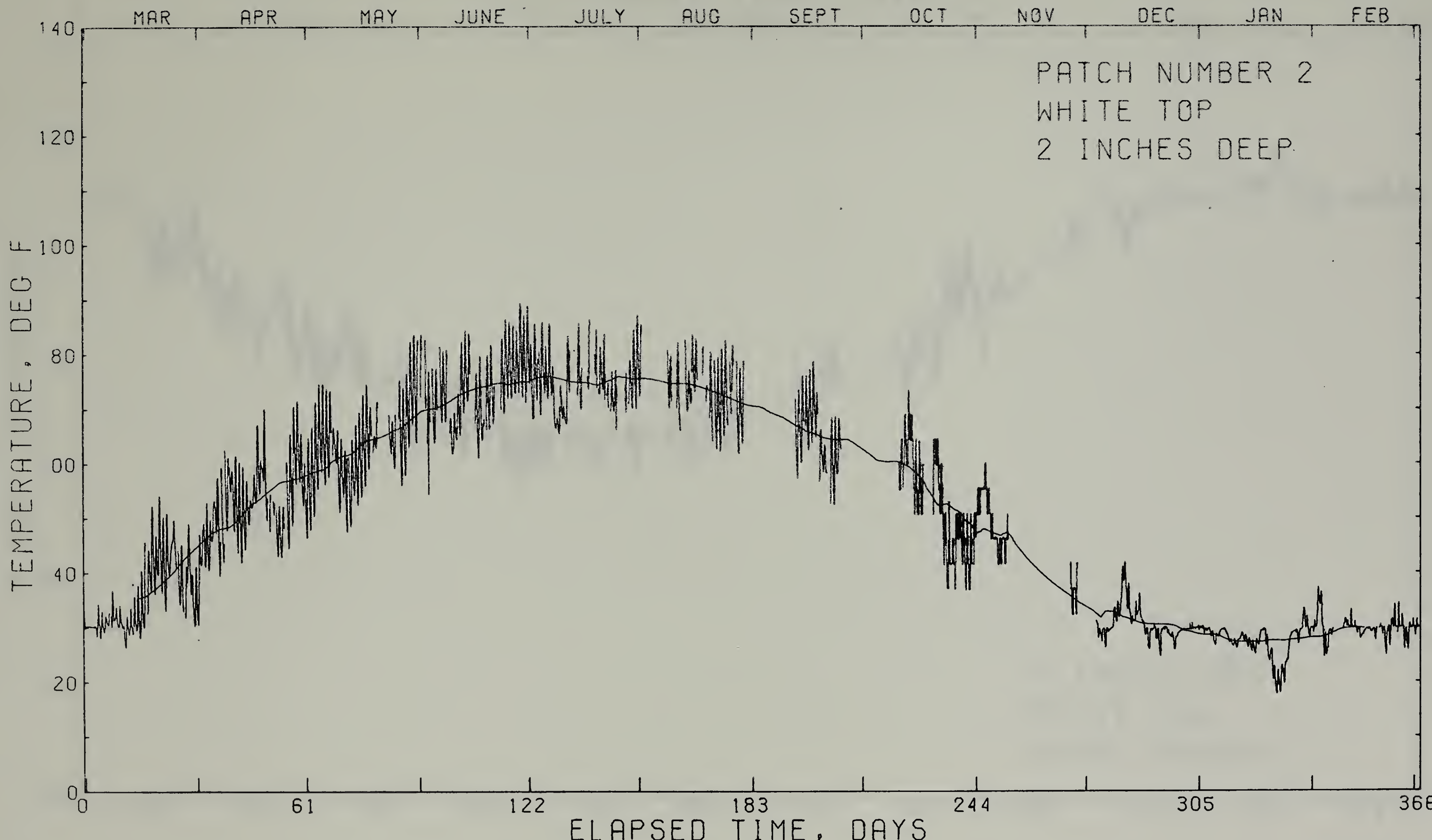

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TOP
2 INCHES DEEP
TEMPERATURE, DEG F
0
20
40
00
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-15

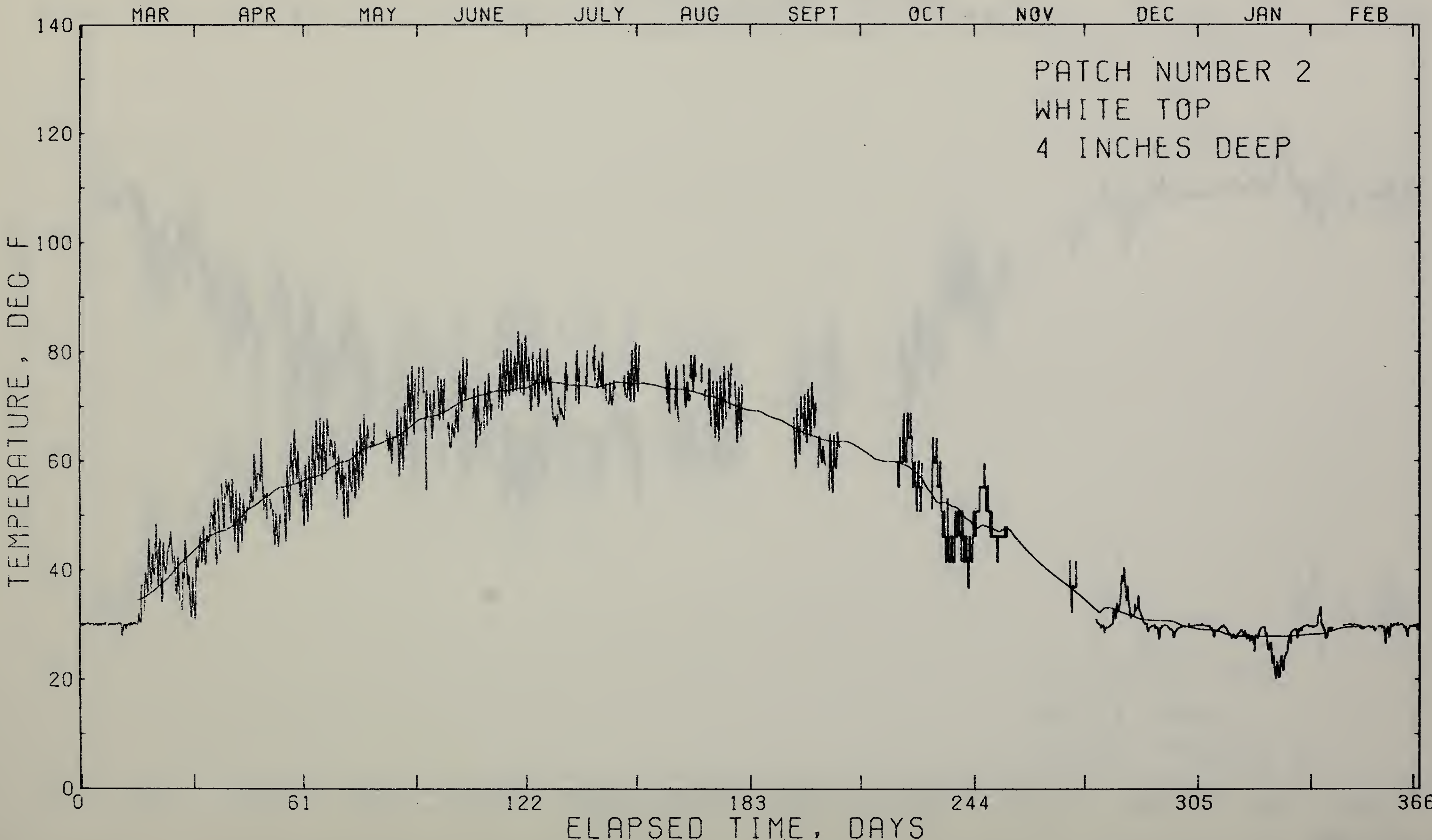

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TOP
4 INCHES DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-16

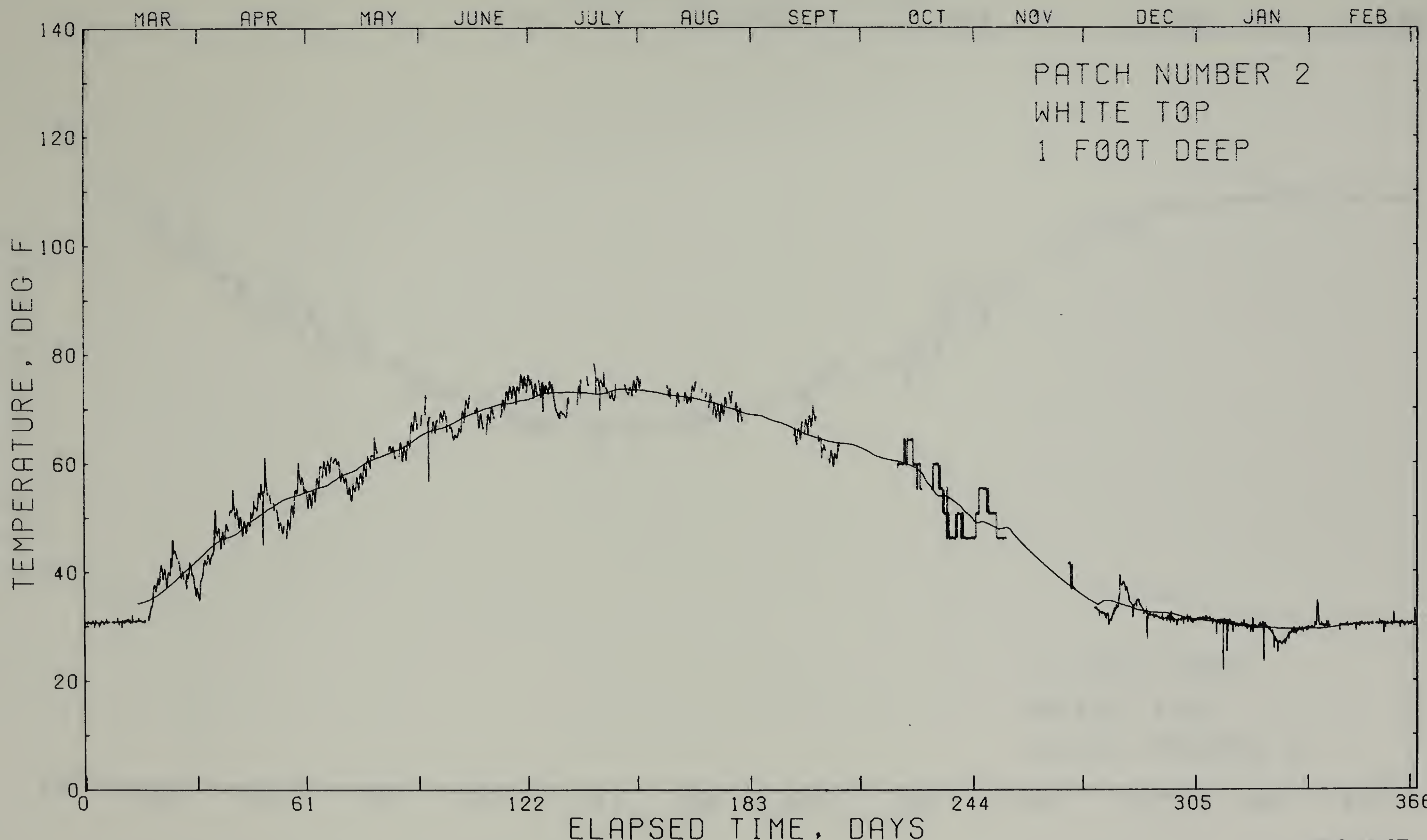
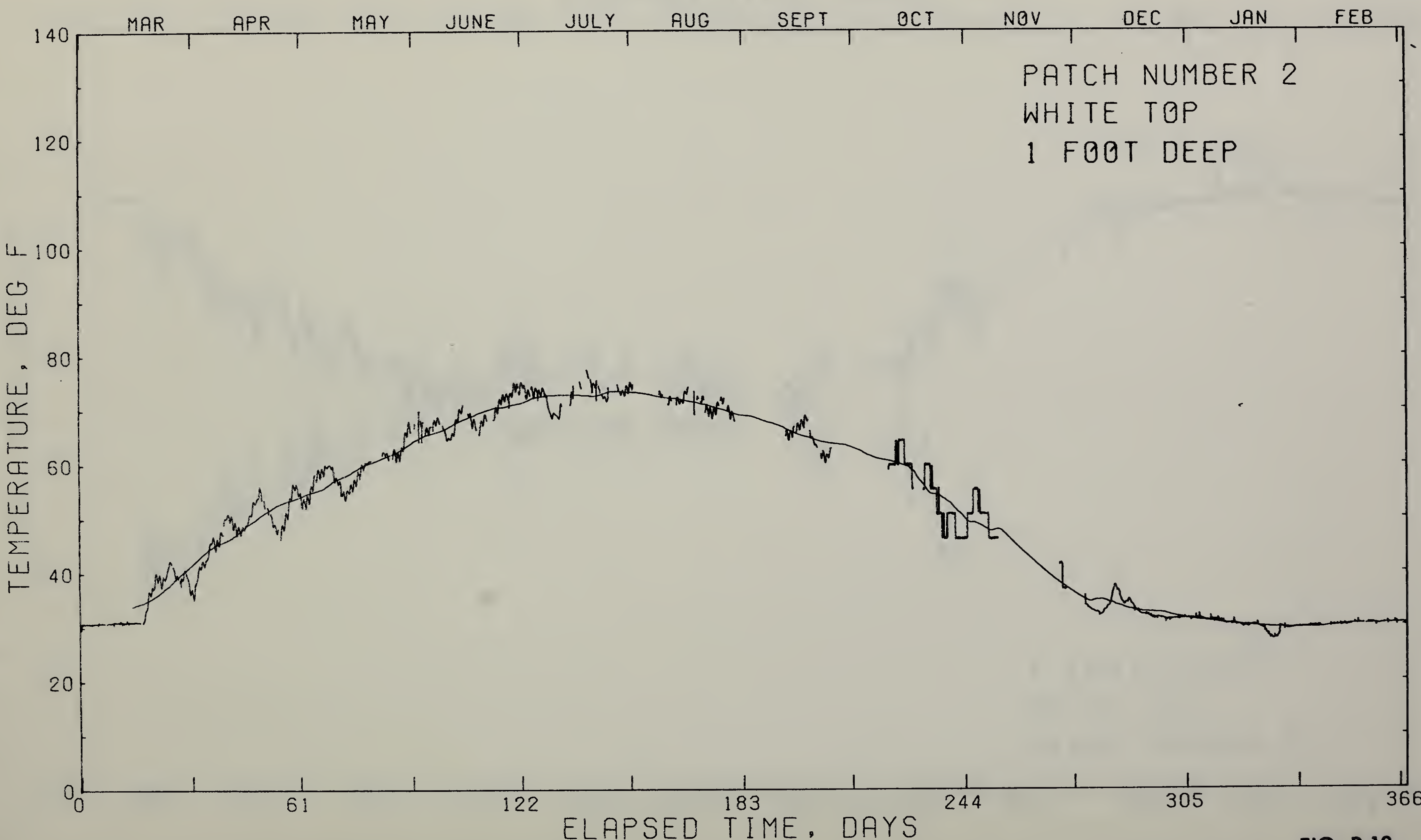

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NØV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TØP
1 FØØT DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-17


MAR
APR
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JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TOP
1 FOOT DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-18

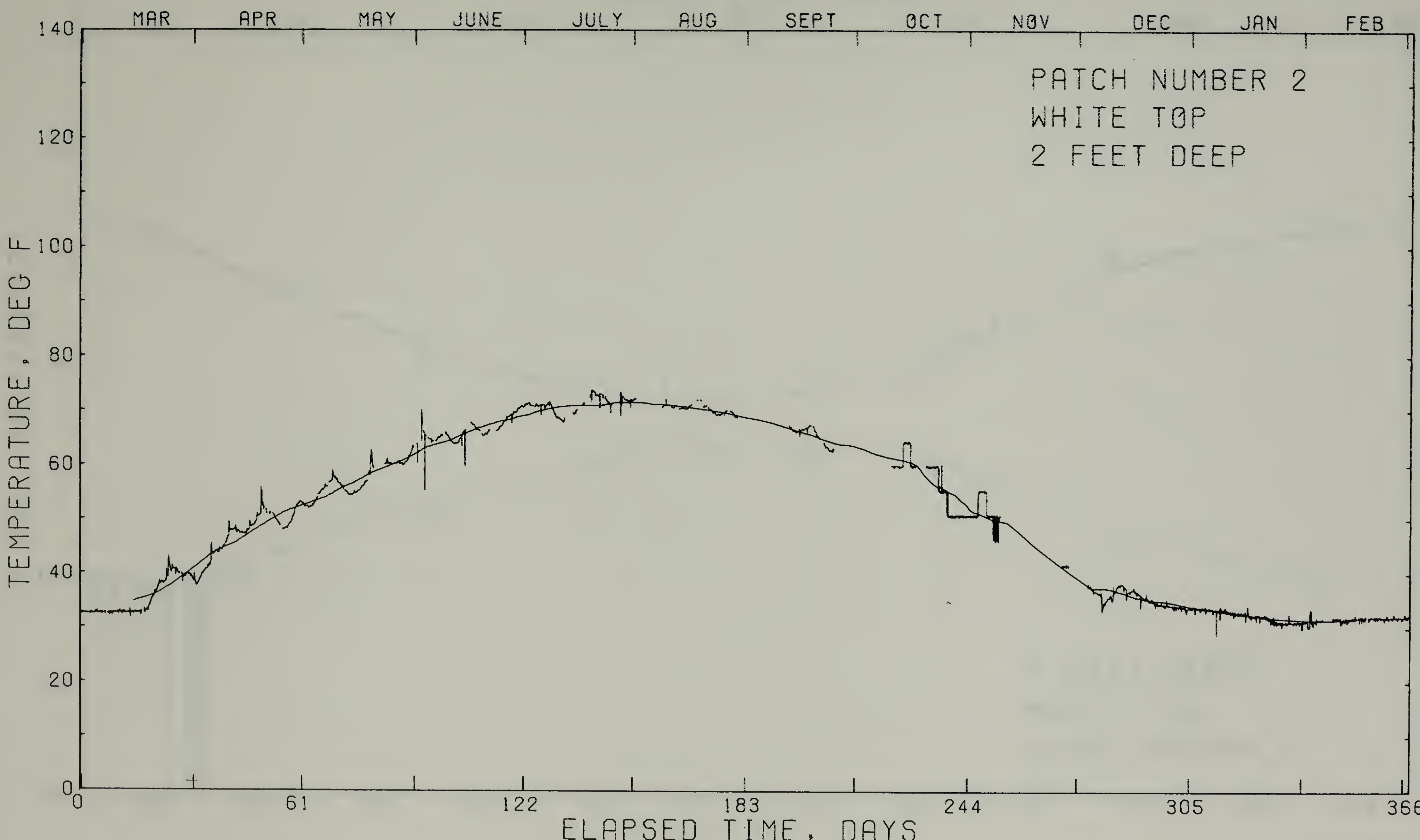
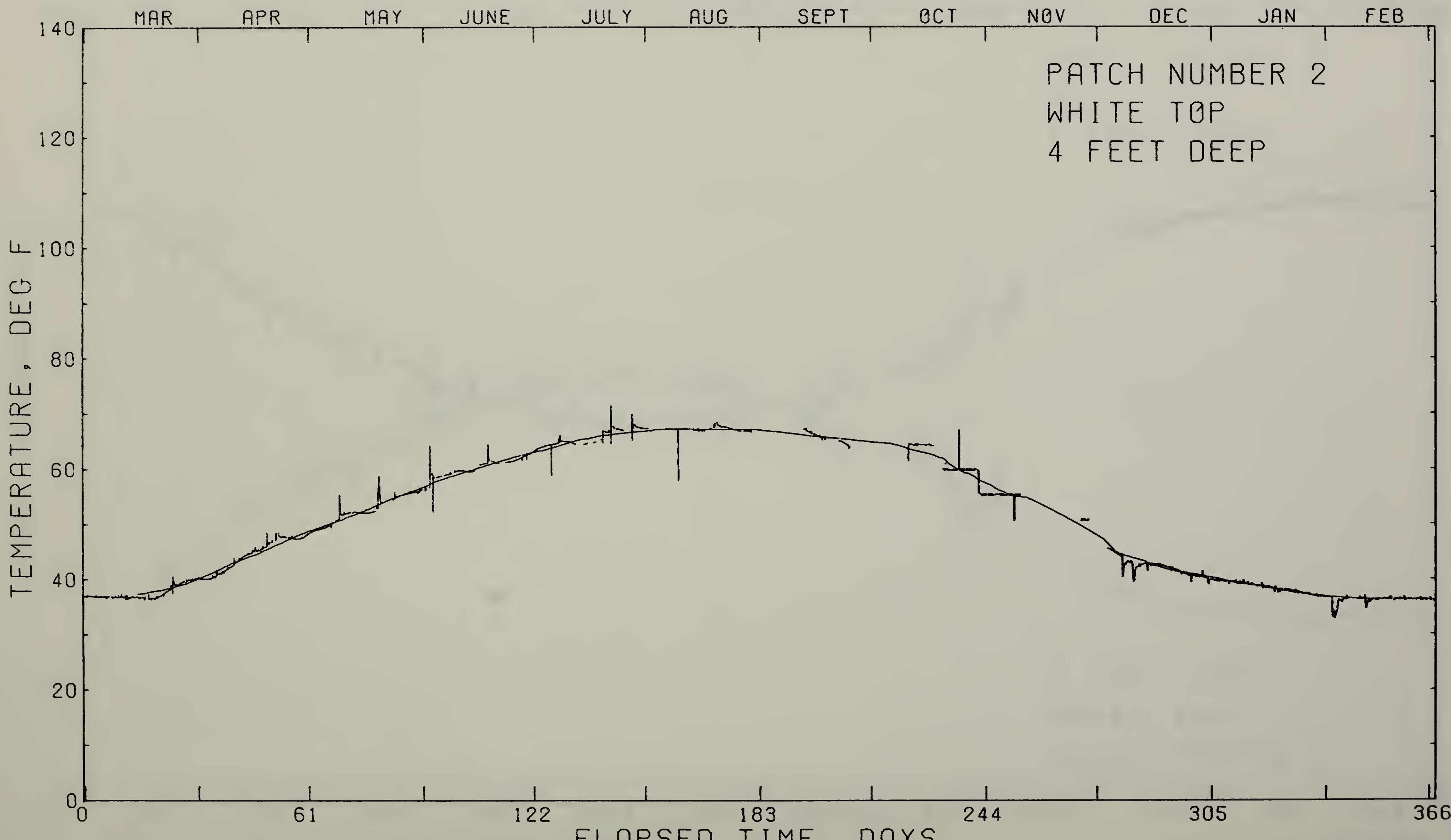

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TOP
2 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-19



MAR
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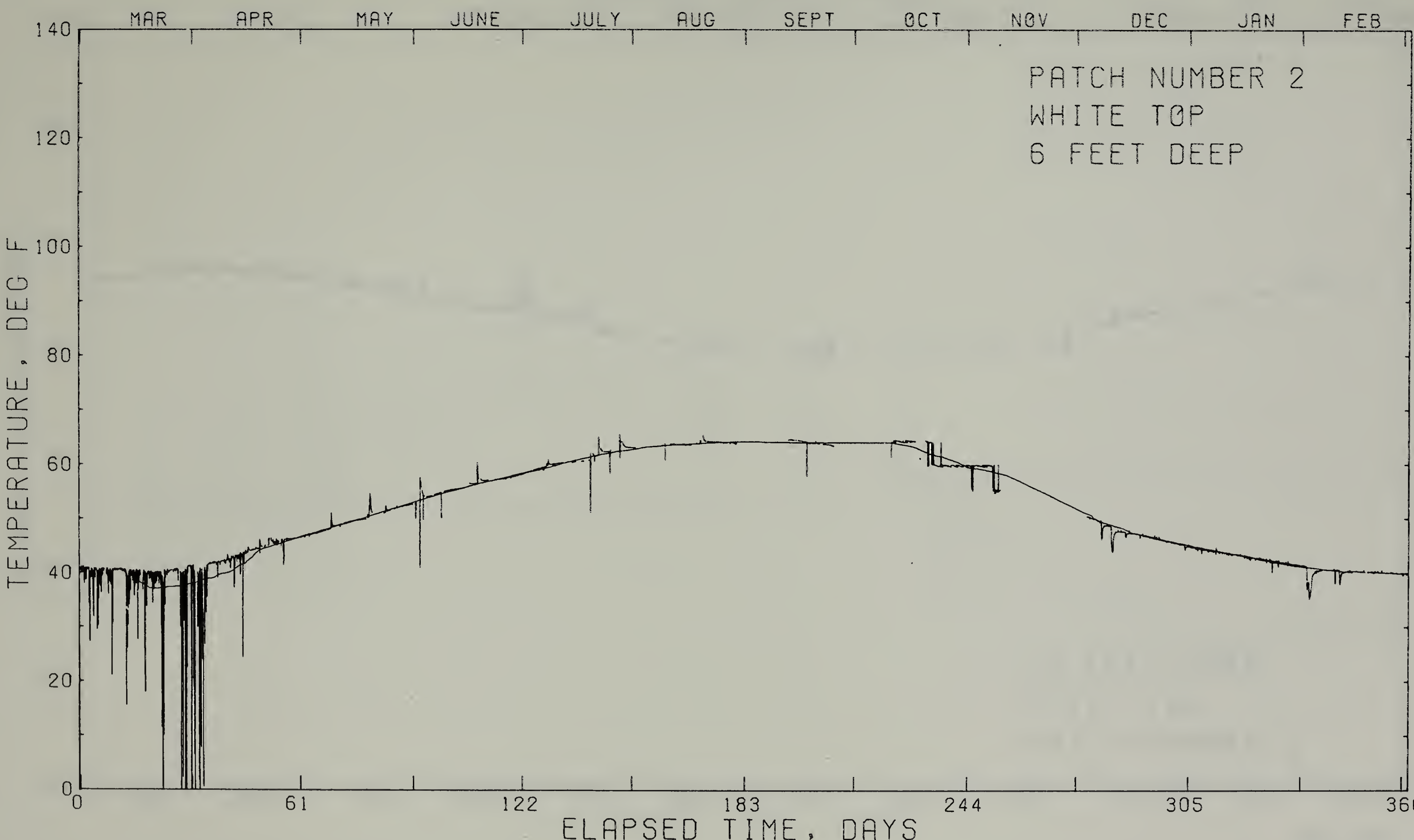
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TOP
4 FEET DEEP
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-20



MAR
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JUNE
JULY
AUG
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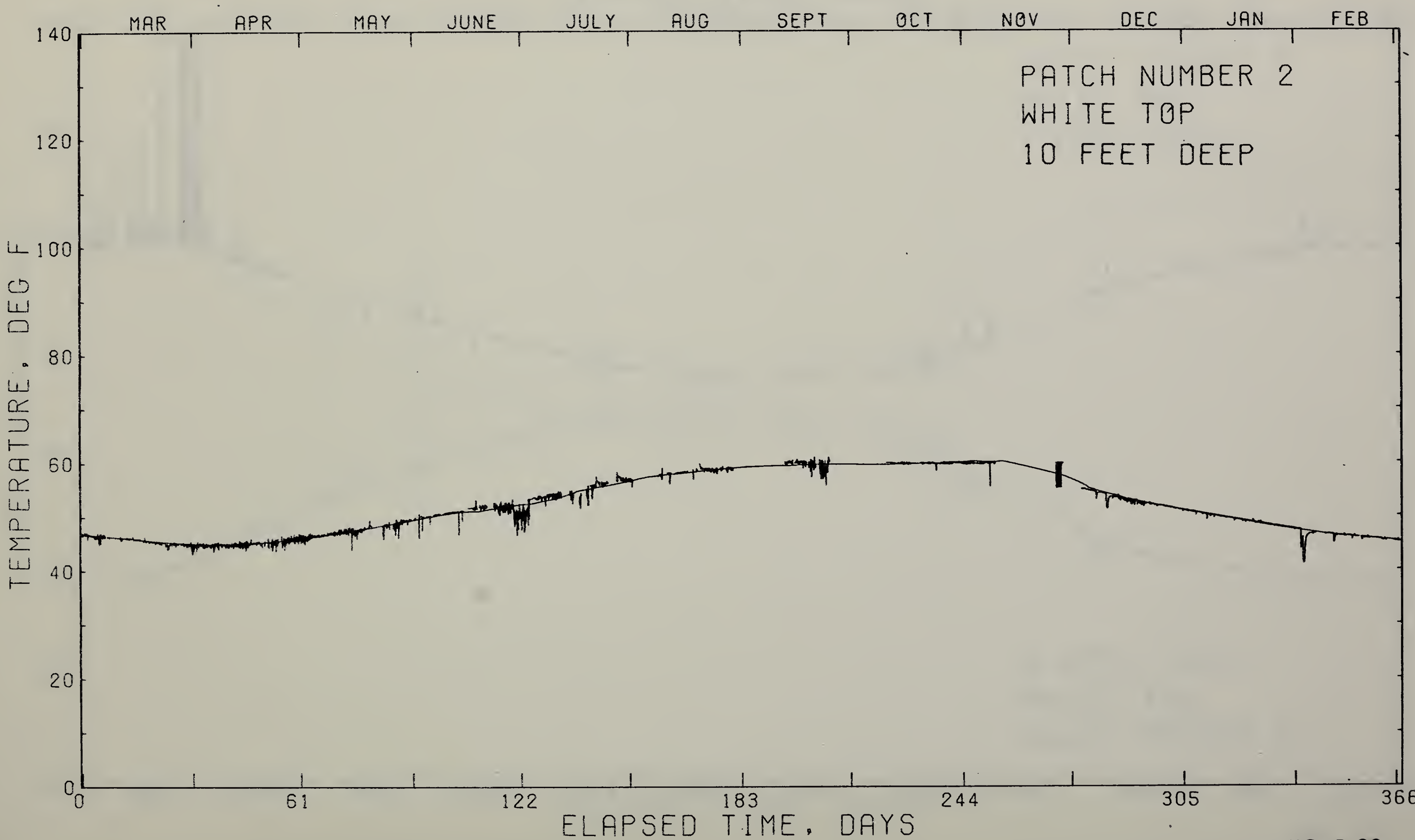
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TOP
6 FEET DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-21


MAR
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MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TOP
10 FEET DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-22

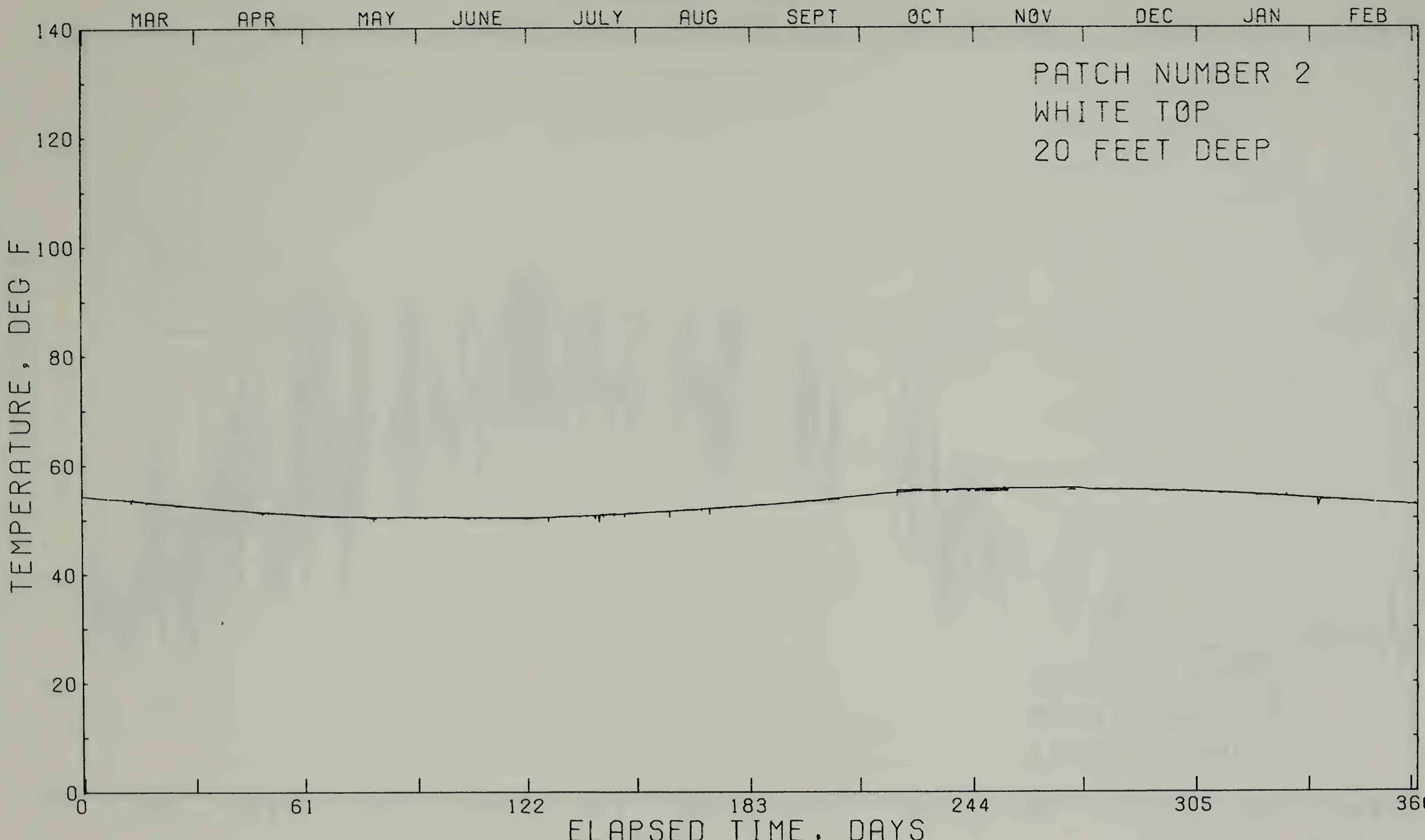
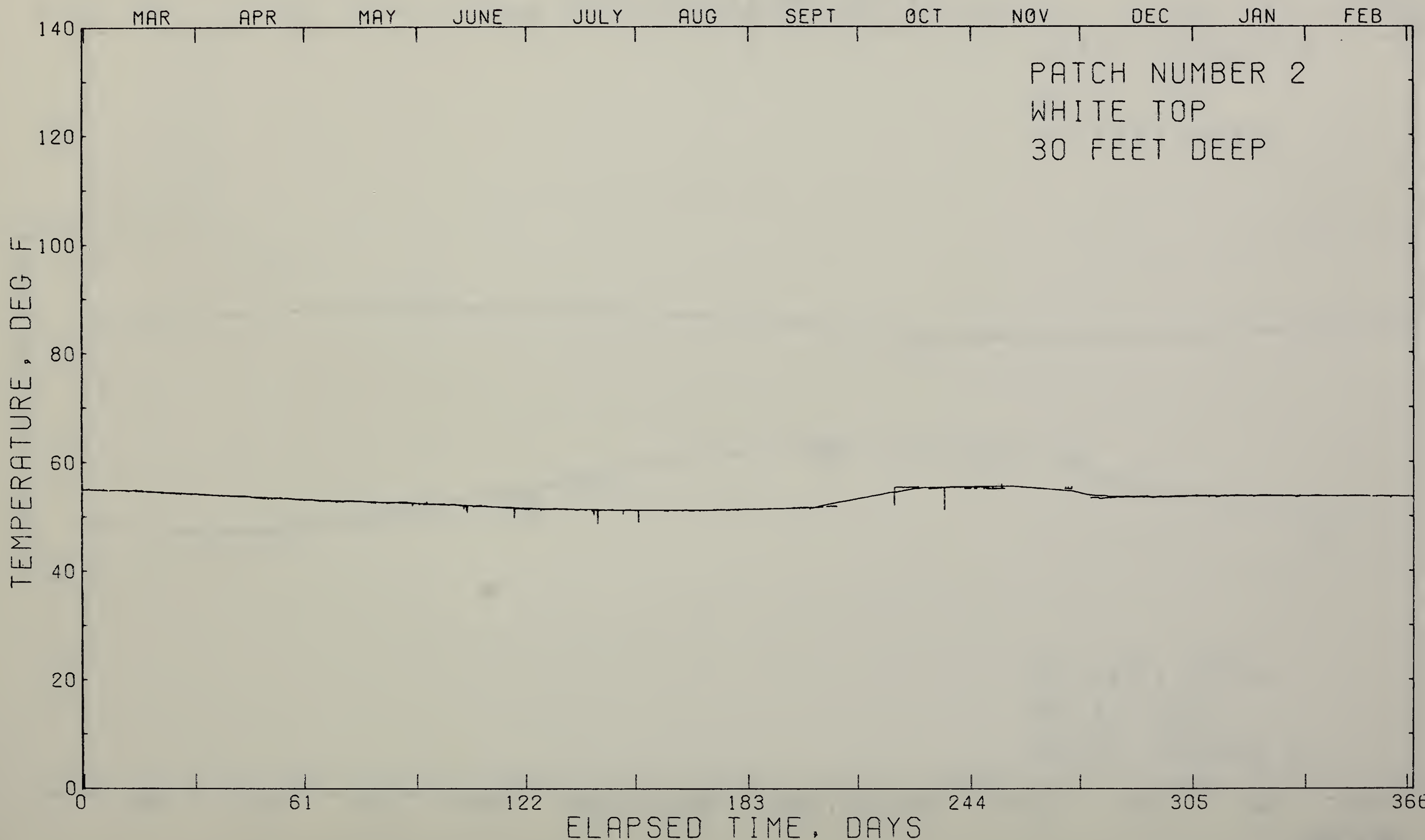

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TOP
20 FEET DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-23



MAR
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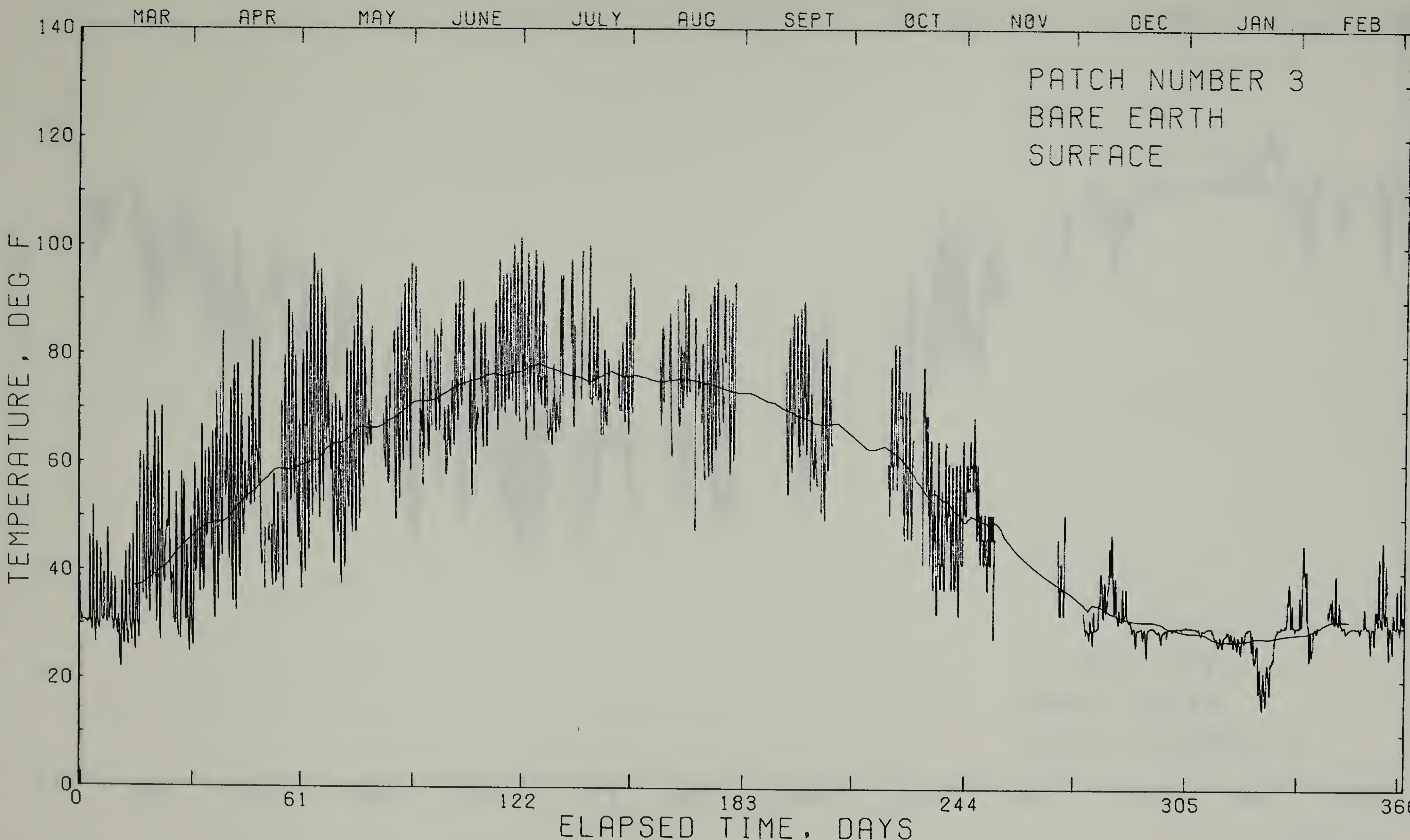
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 2
WHITE TOP
30 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-24



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
SURFACE
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-25

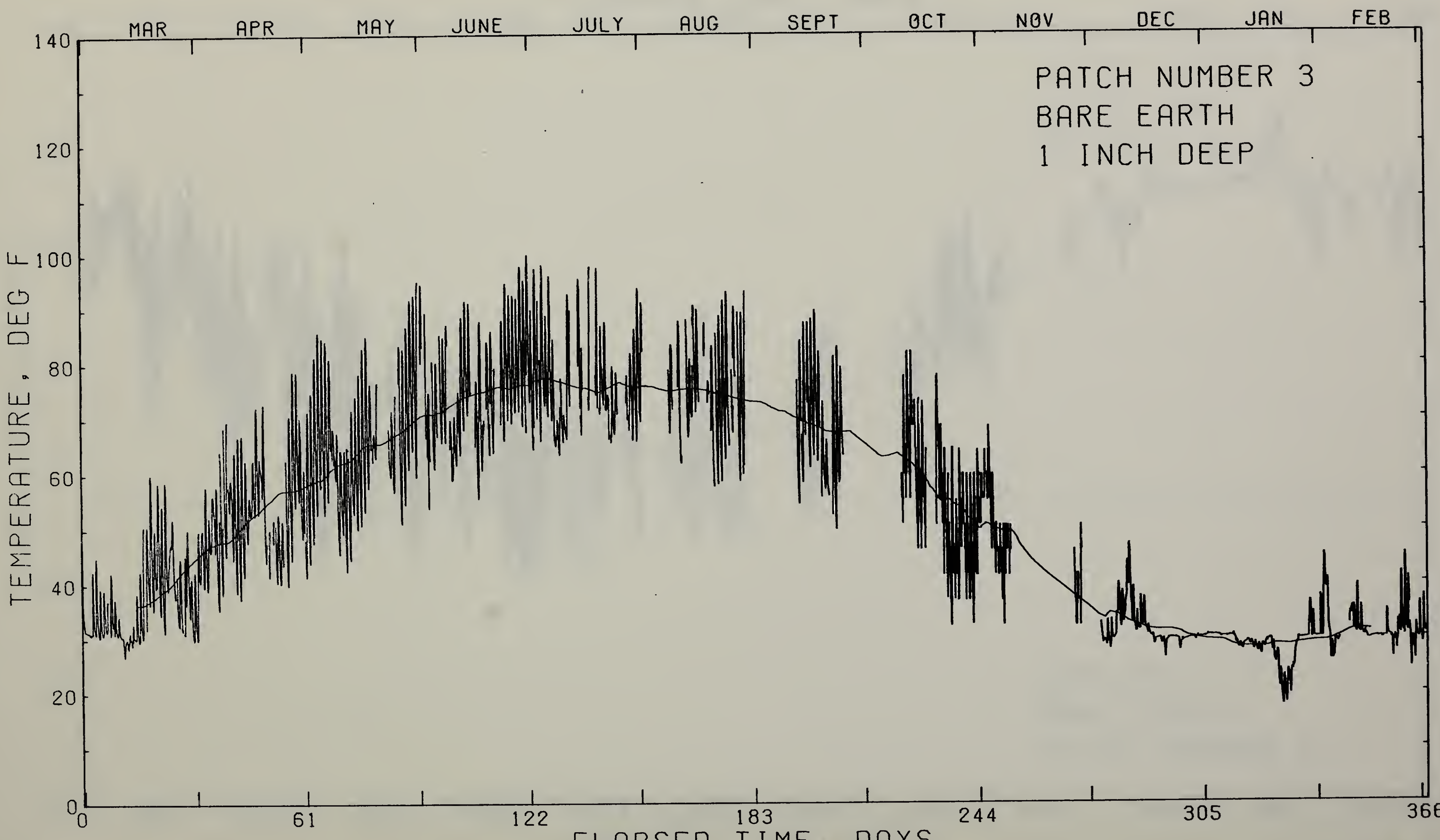

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
1 INCH DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-26

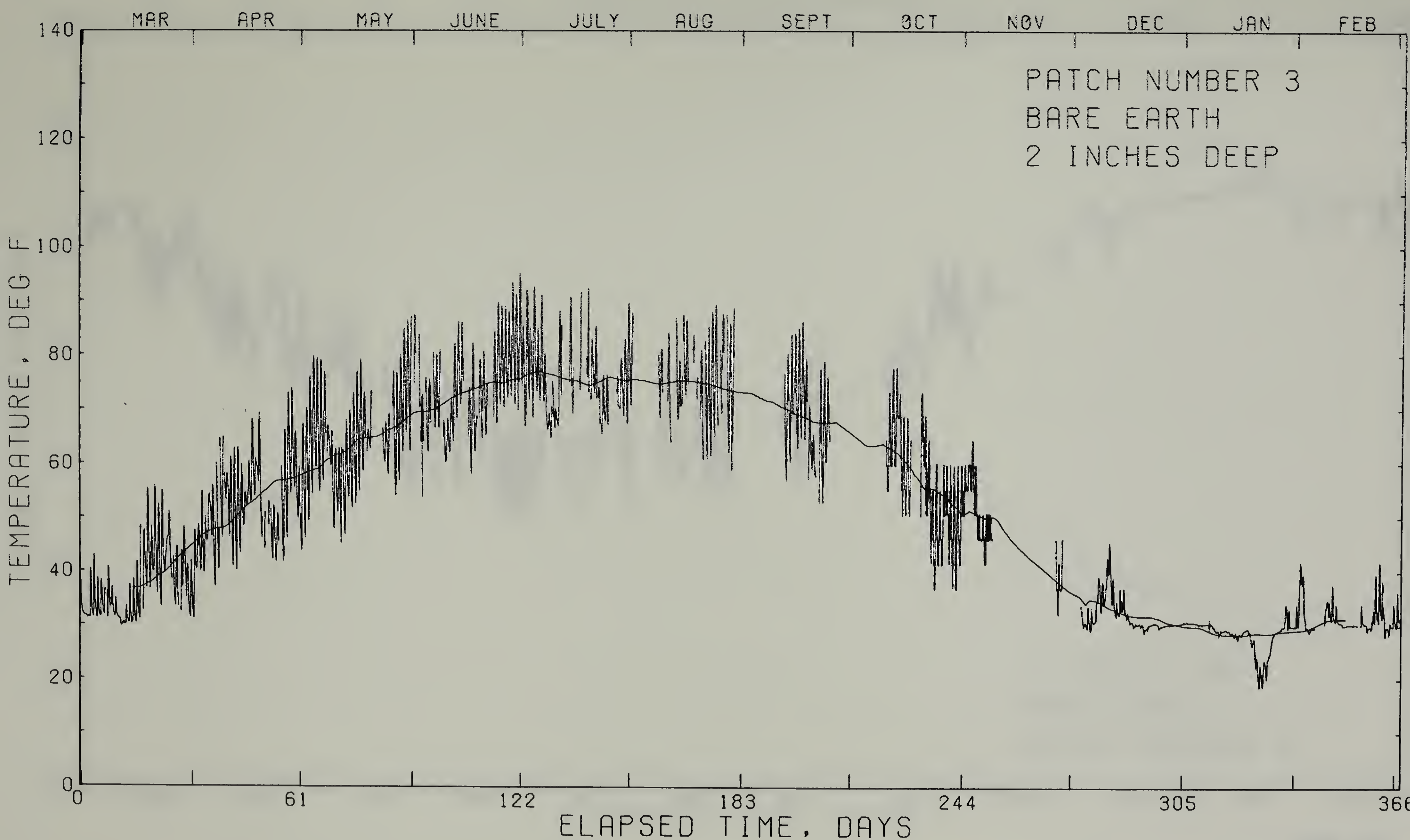

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
2 INCHES DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-27

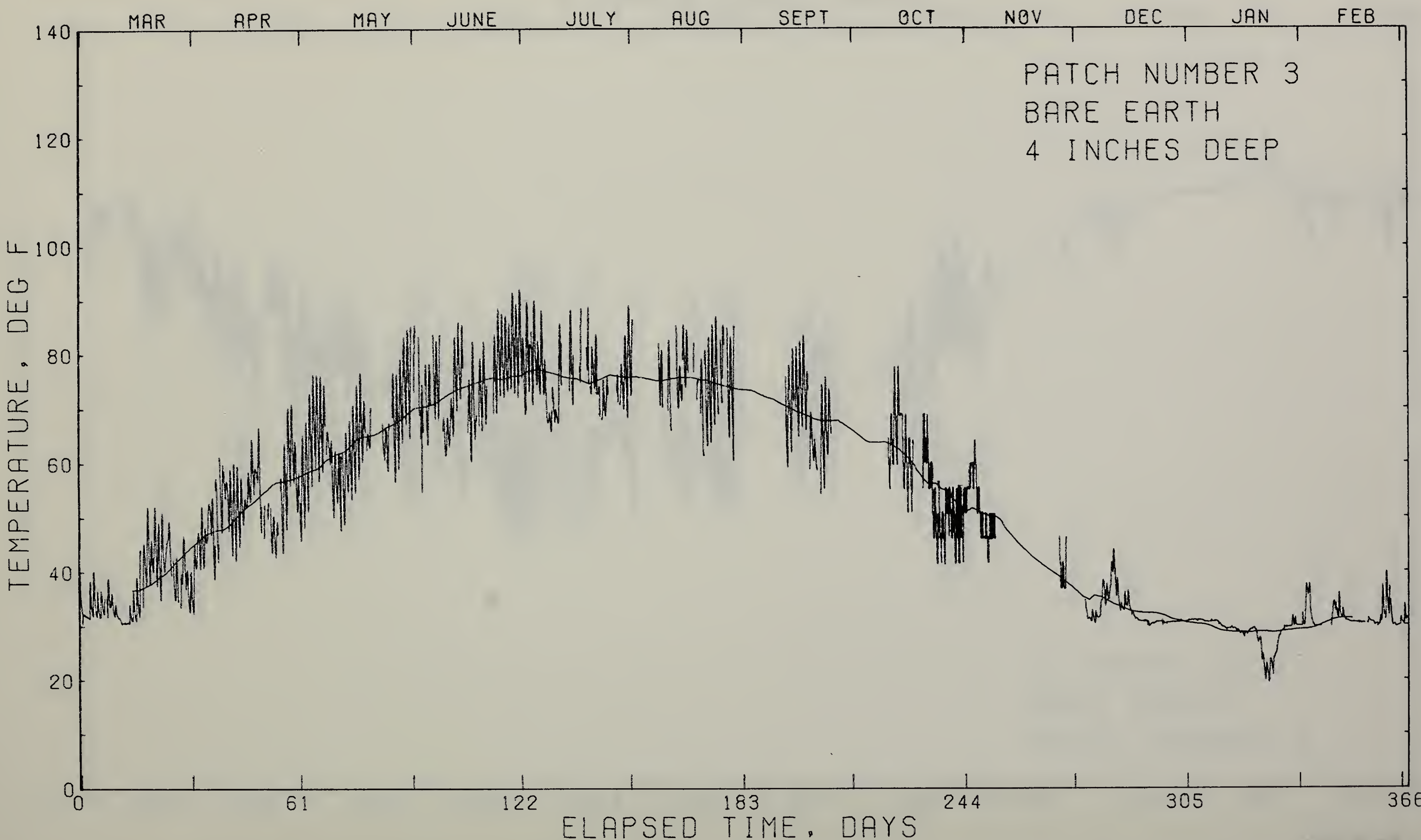

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
4 INCHES DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-28

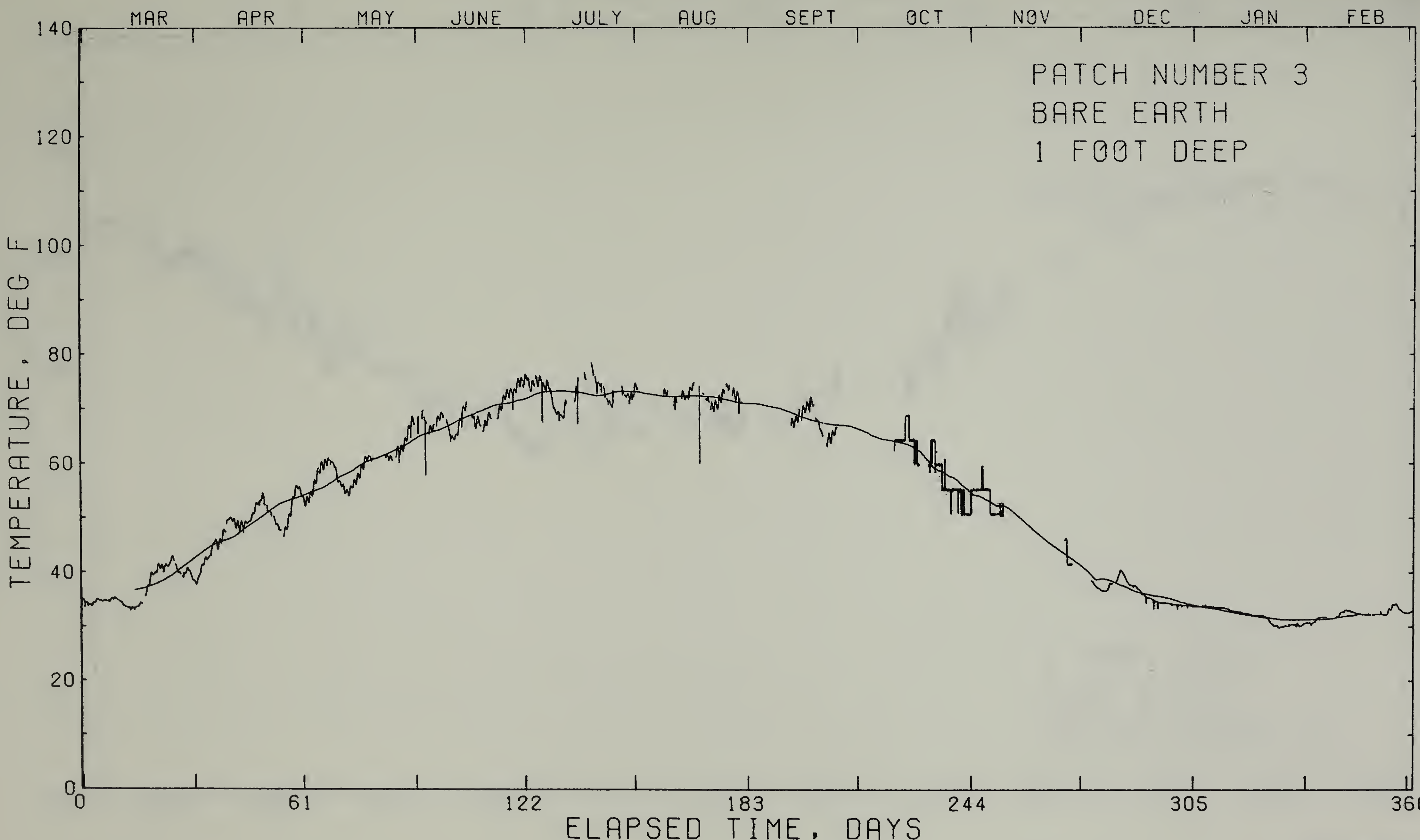
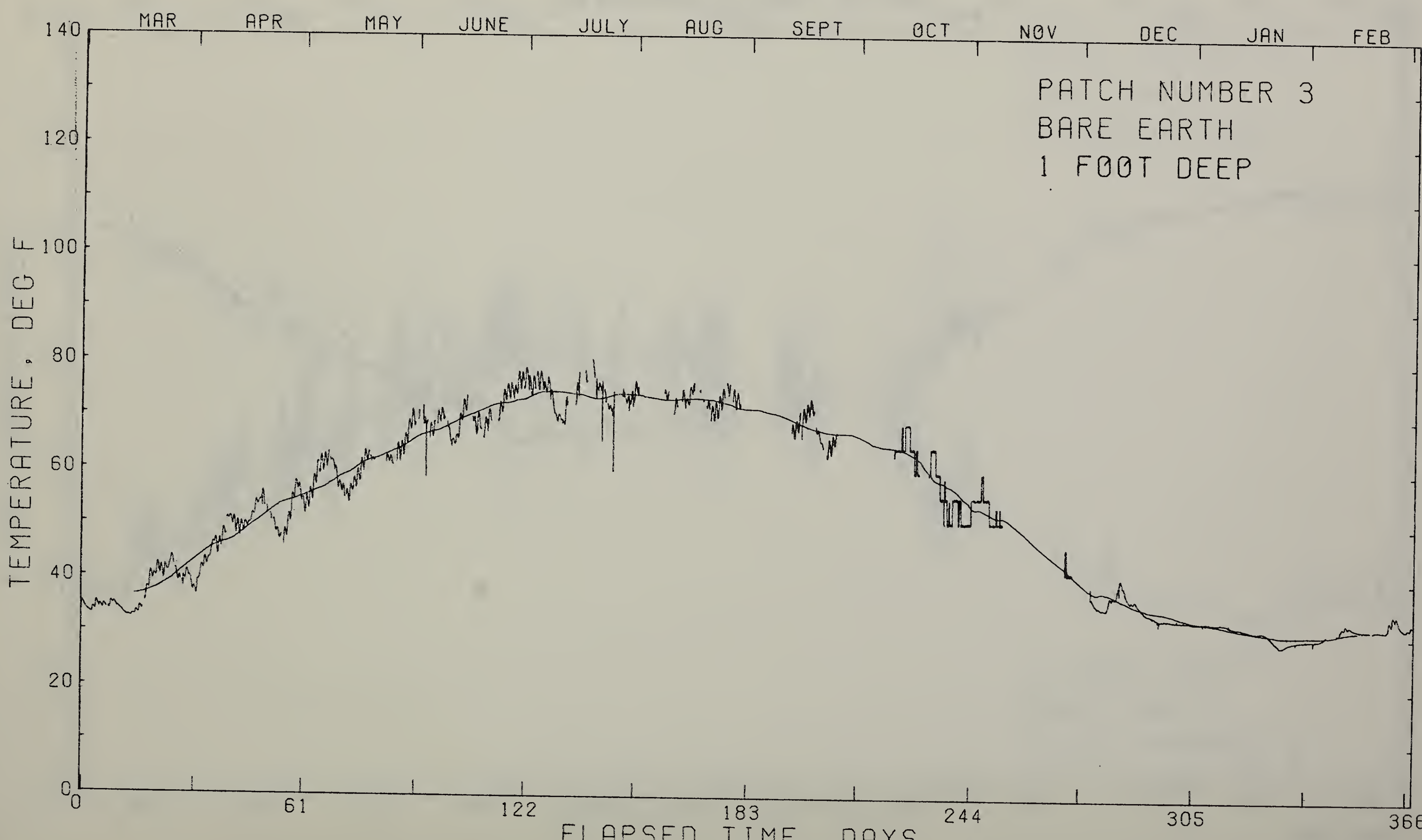
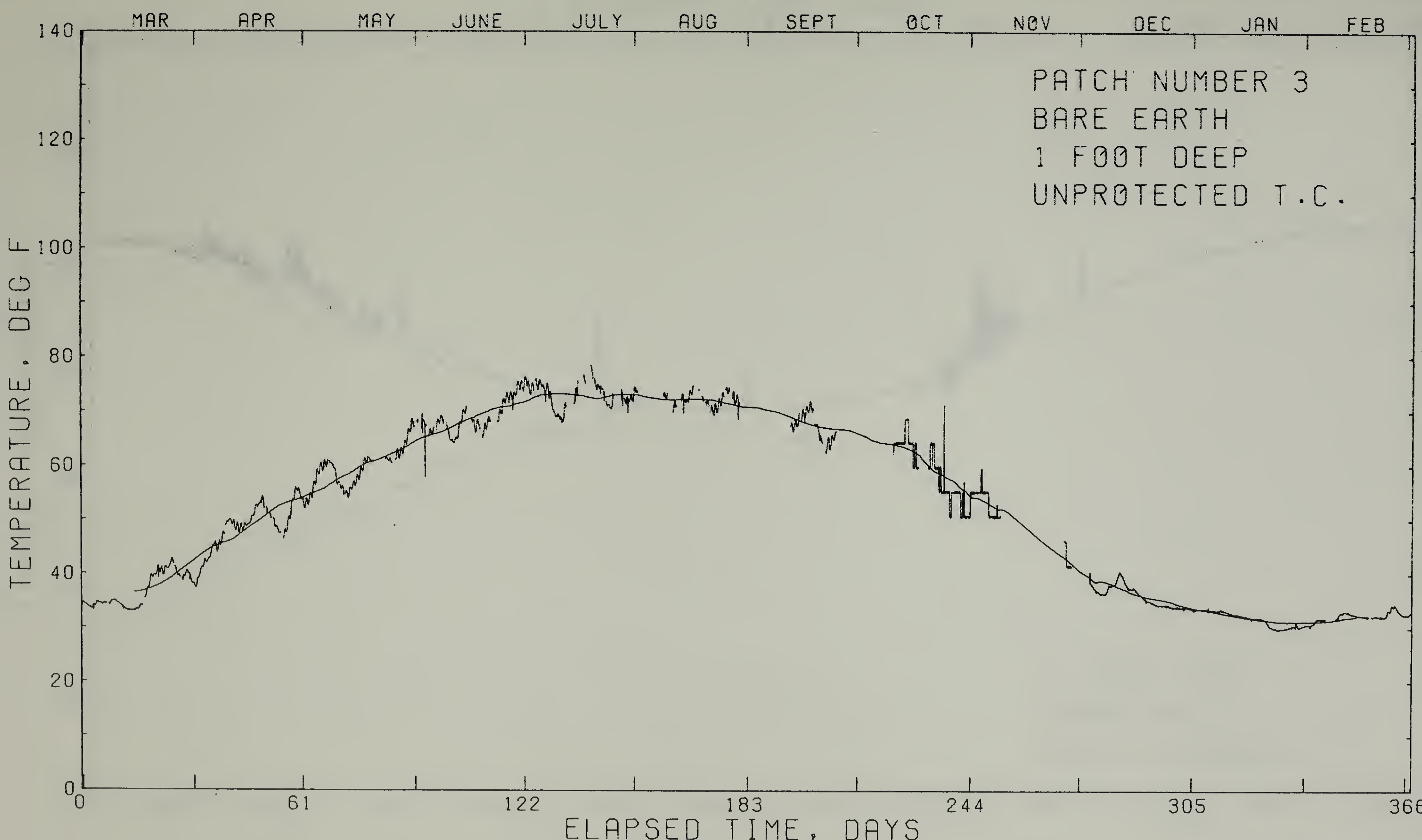

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
1 FOOT DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-29



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
1 FOOT DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-30



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
1 FOOT DEEP
UNPROTECTED T.C.
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-30A

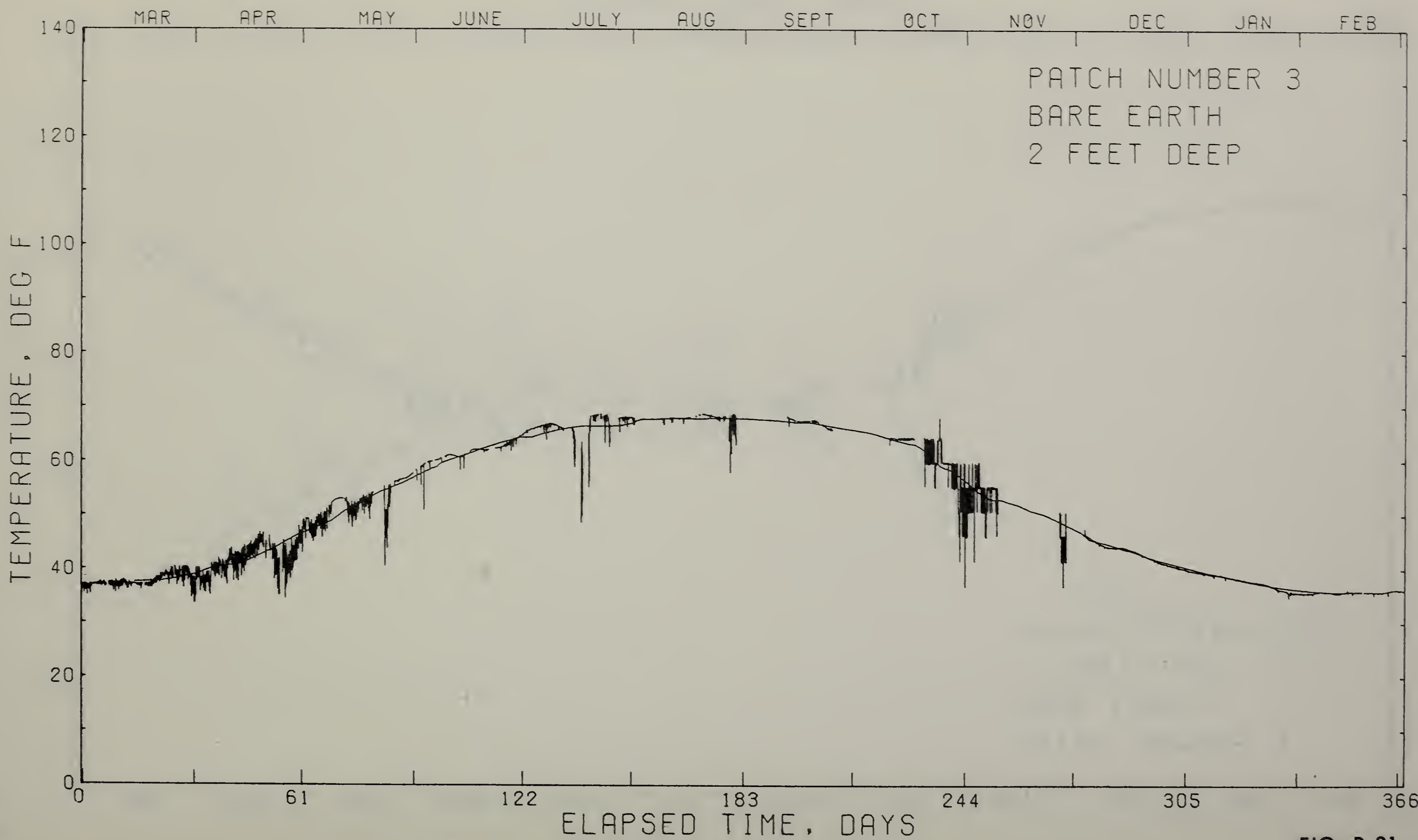

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
2 FEET DEEP
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-31

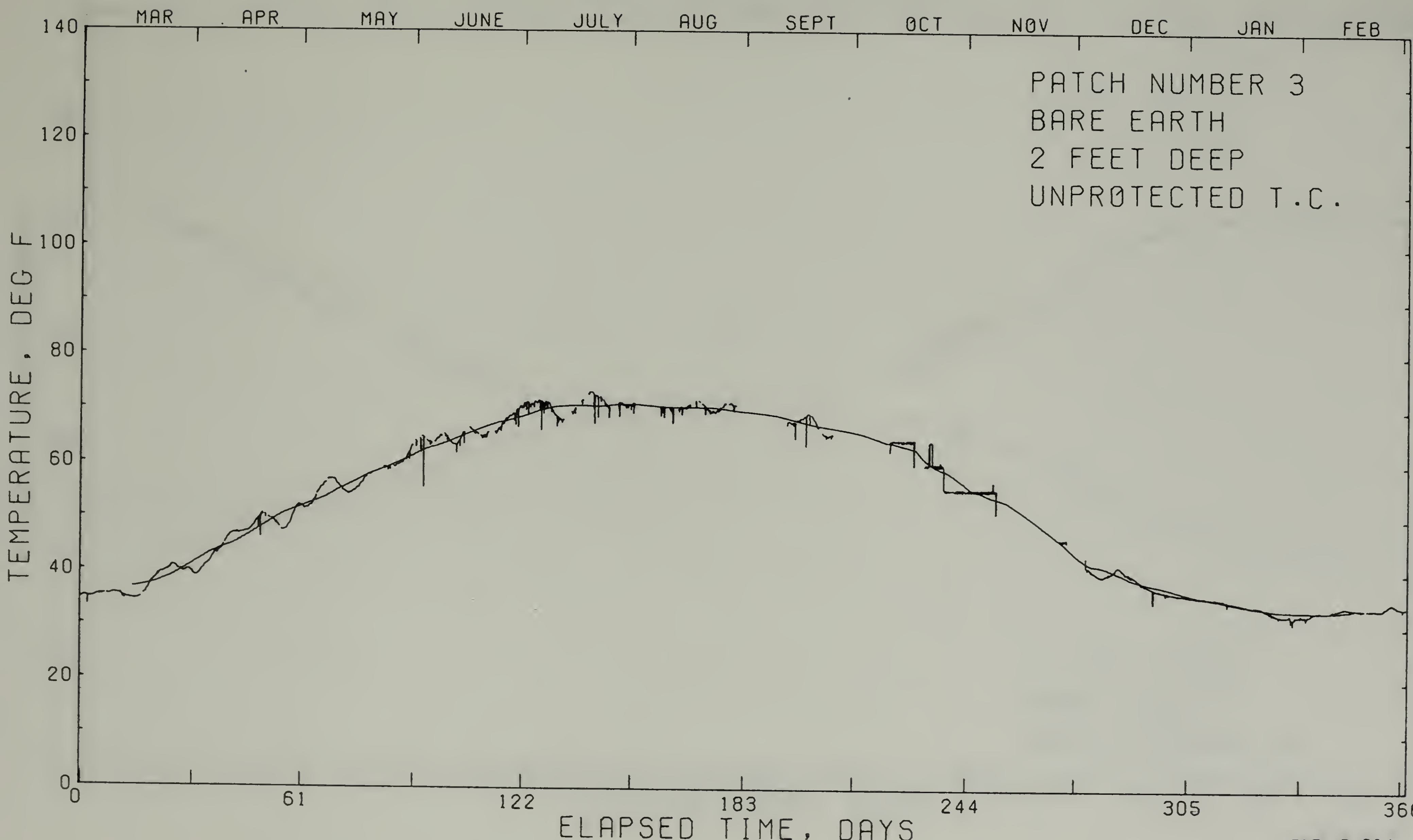

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
2 FEET DEEP
UNPROTECTED T.C.
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-31A

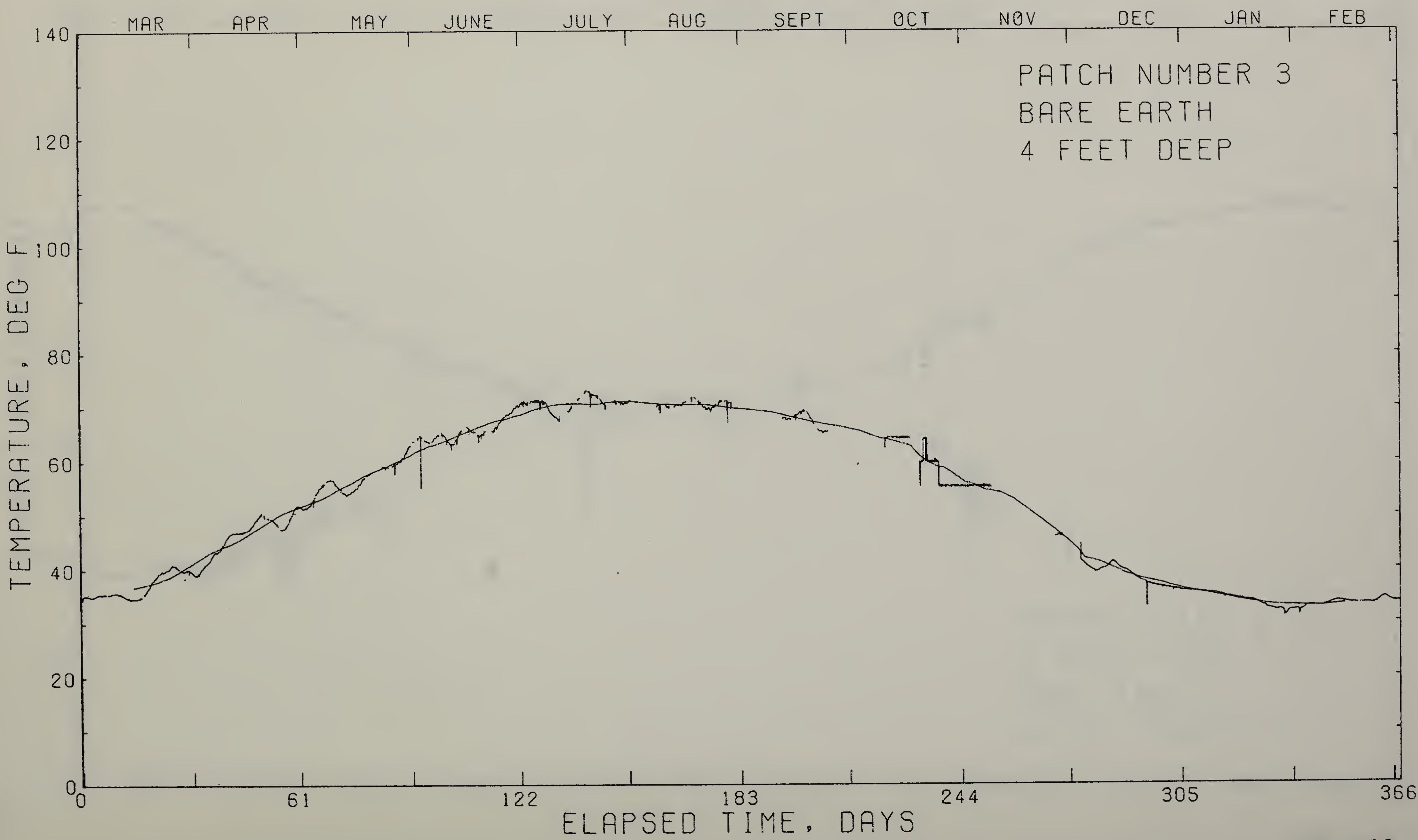

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
4 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-32

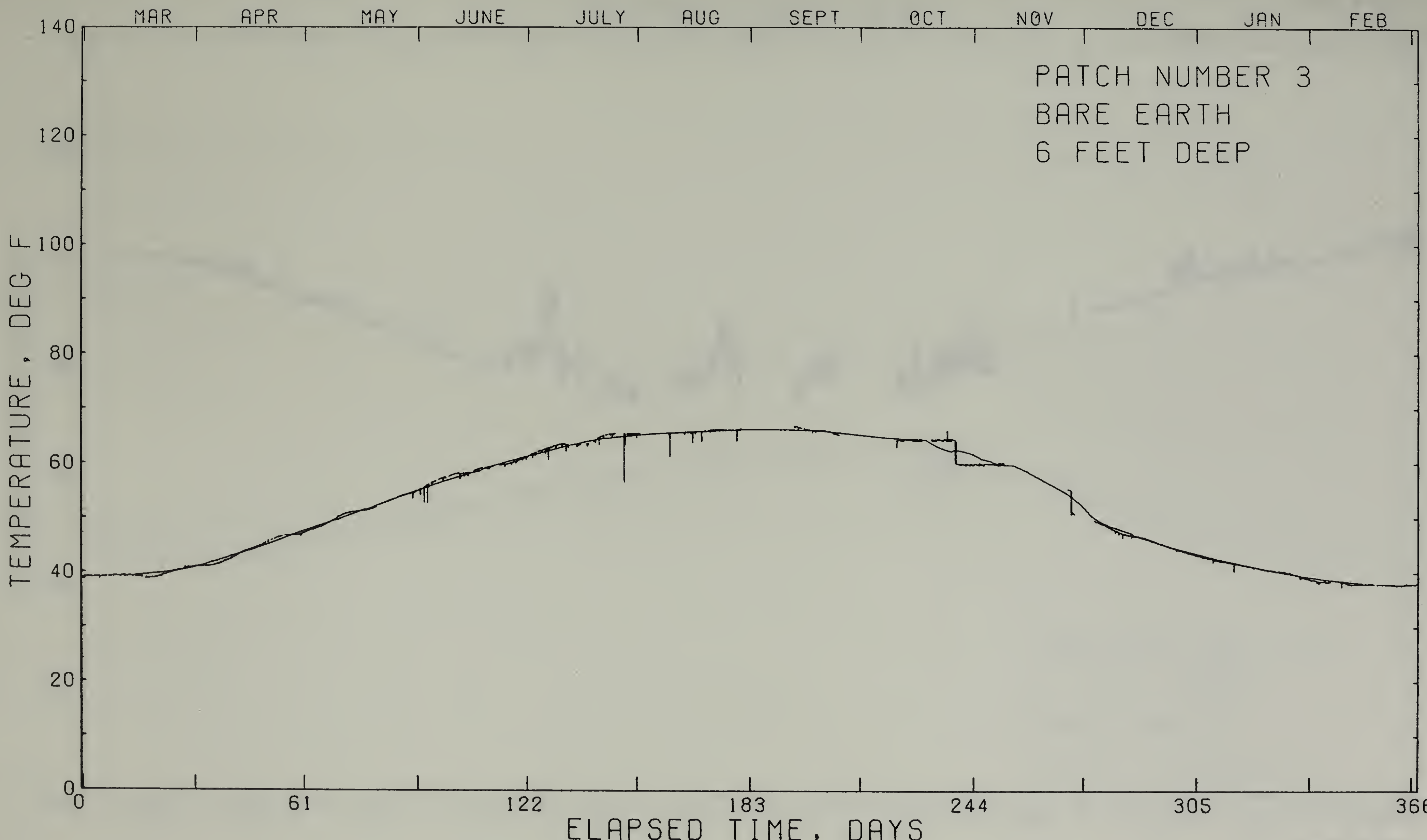

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
6 FEET DEEP
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-33

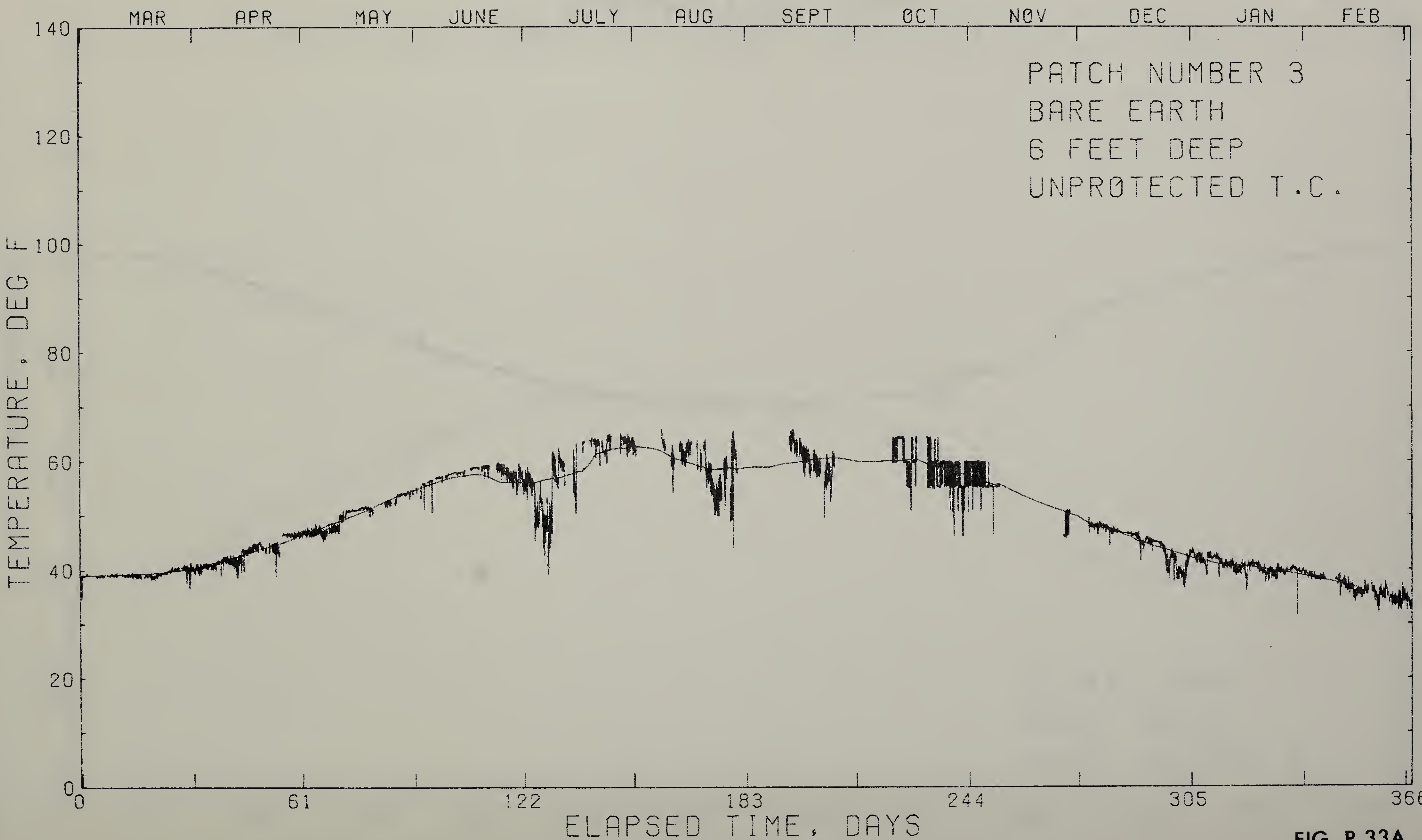

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
6 FEET DEEP
UNPROTECTED T.C.
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-33A

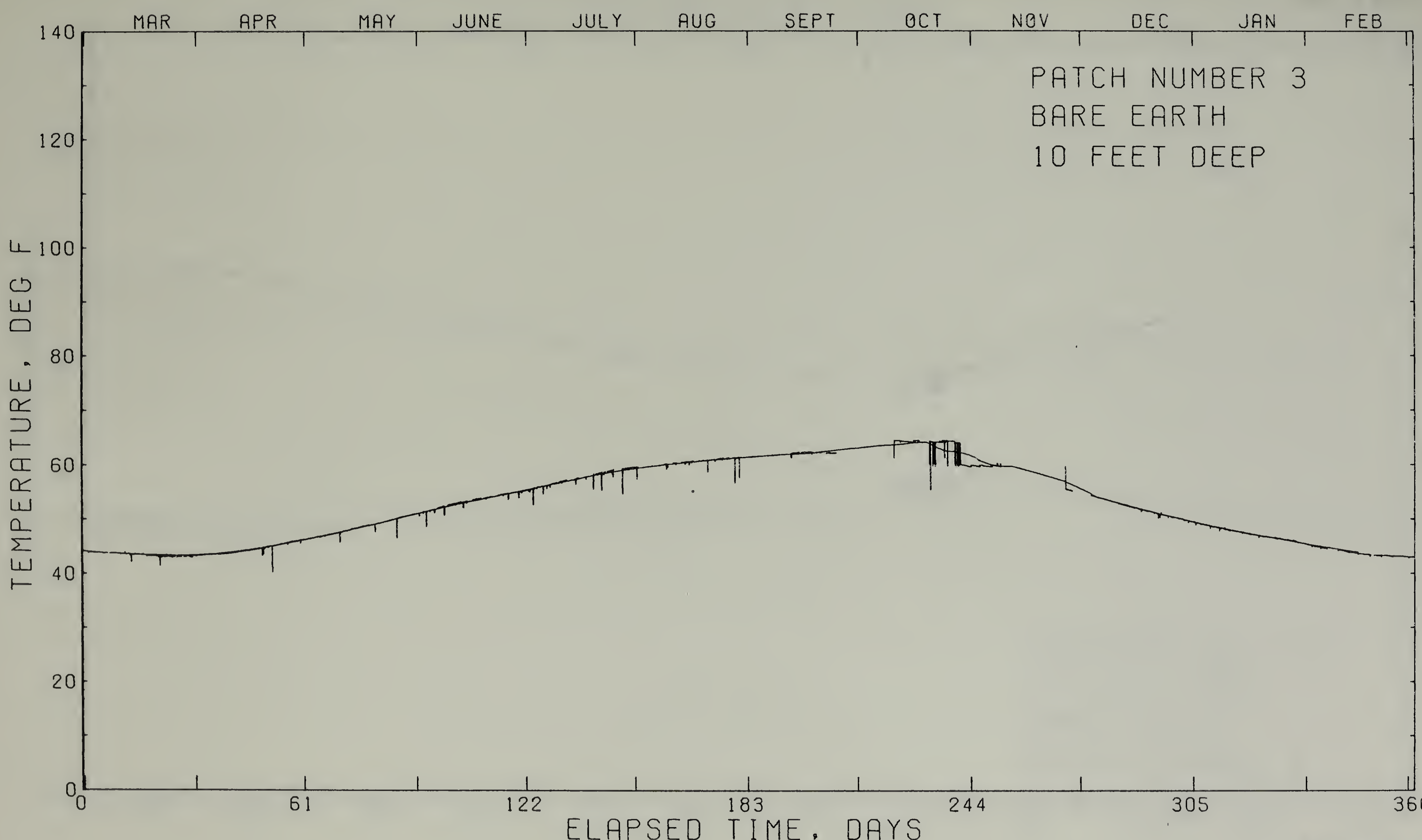
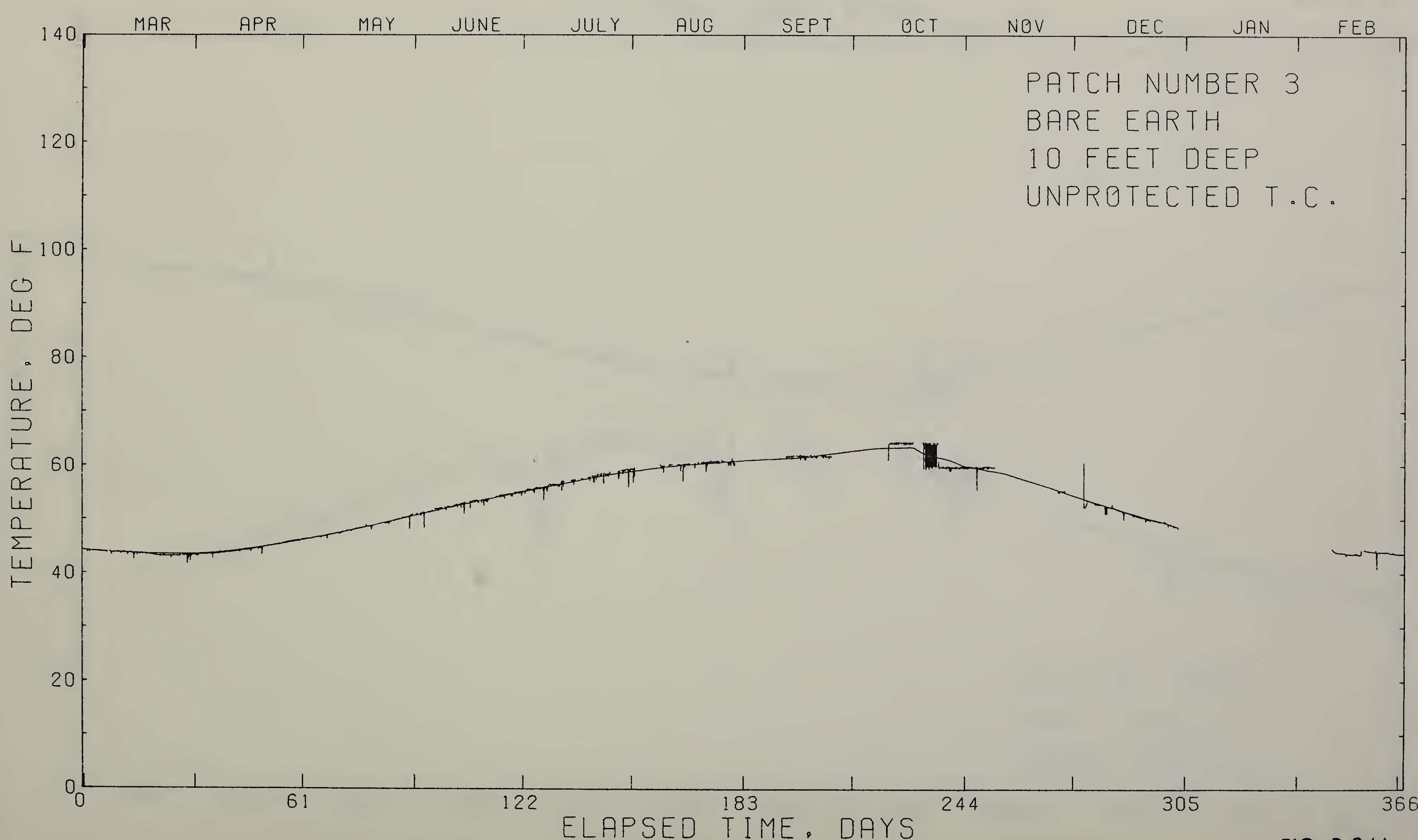

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
10 FEET DEEP
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-34



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
10 FEET DEEP
UNPROTECTED T.C.
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-34A

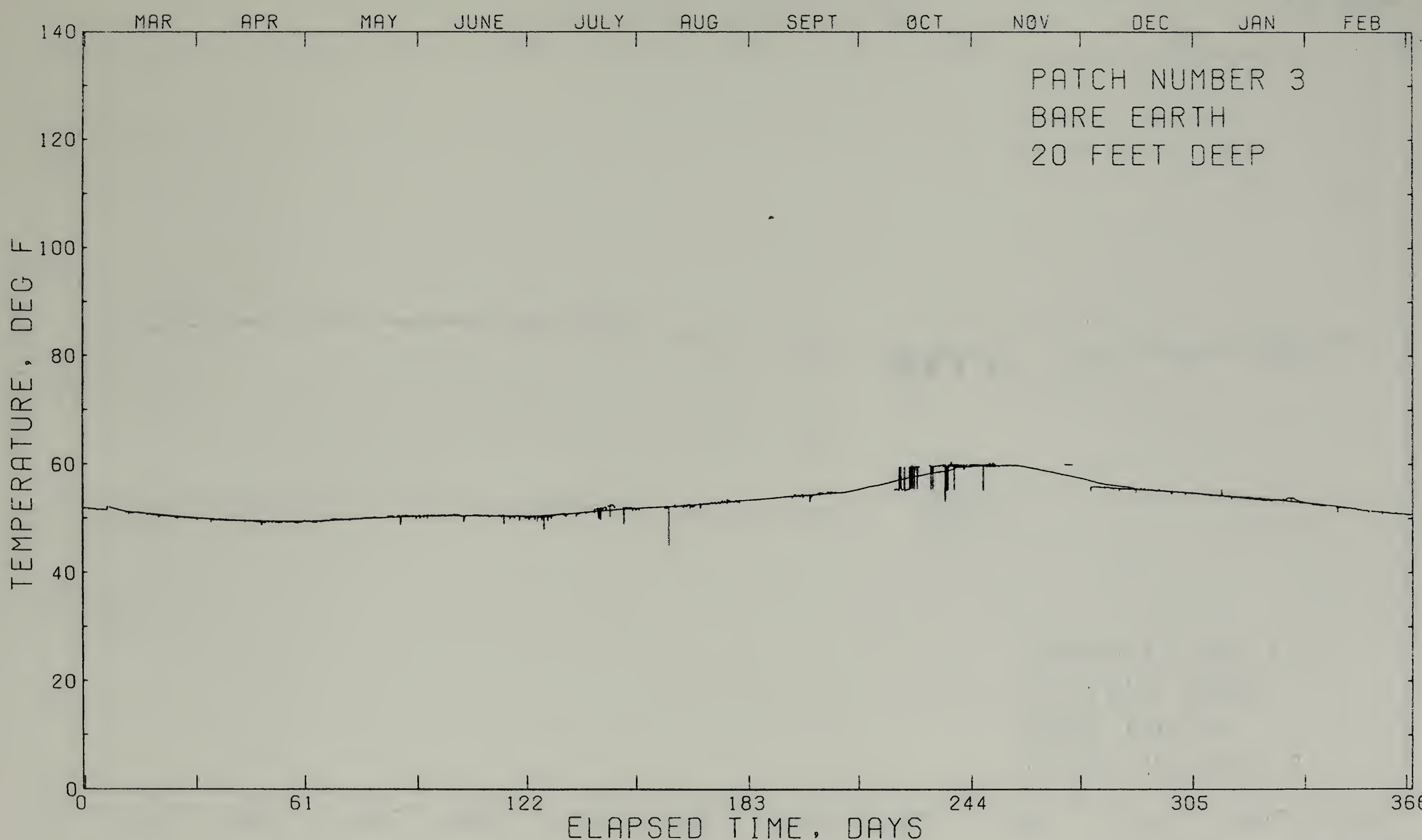

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
20 FEET DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-35

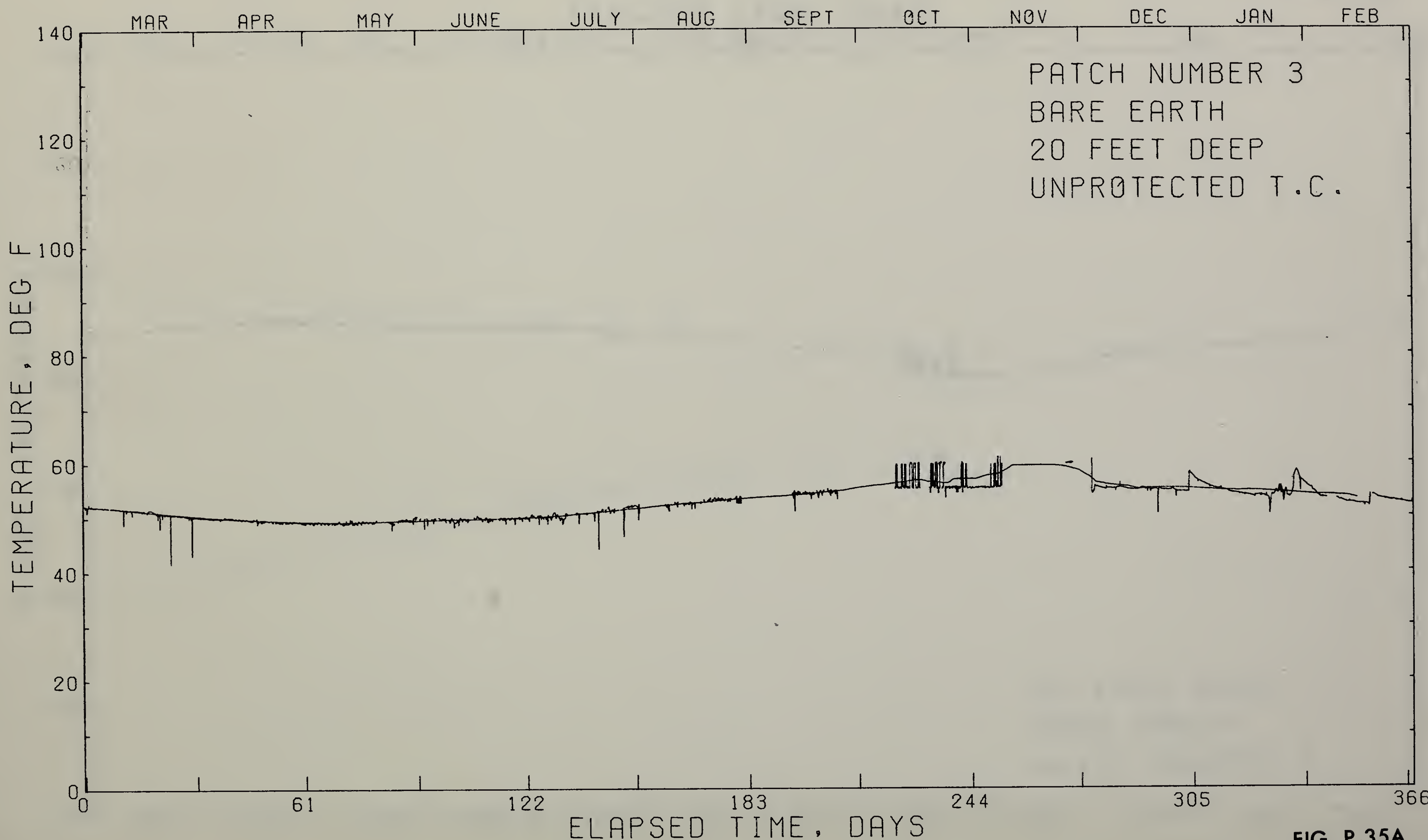

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
20 FEET DEEP
UNPROTECTED T.C.
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-35A

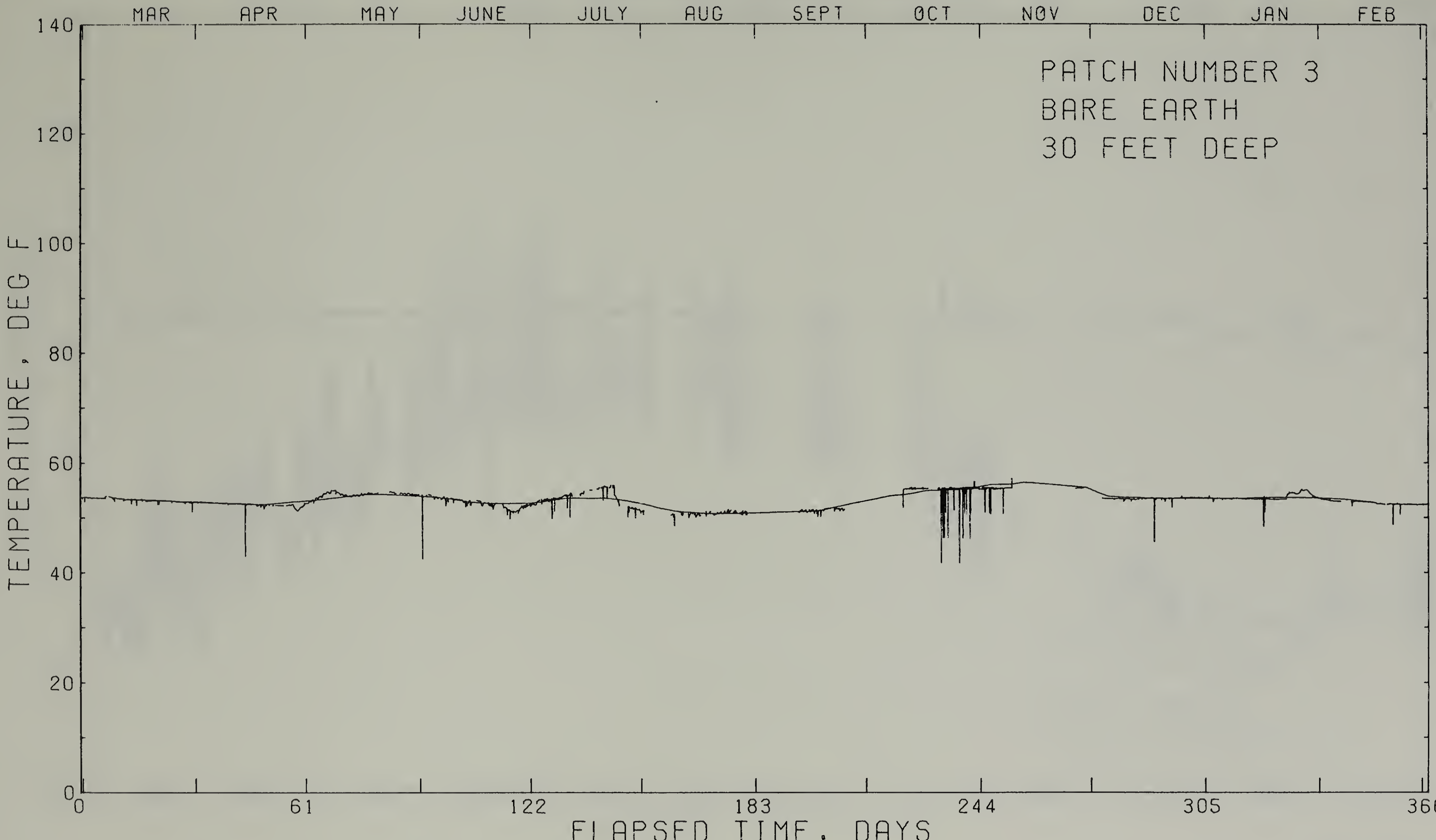

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
30 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-36

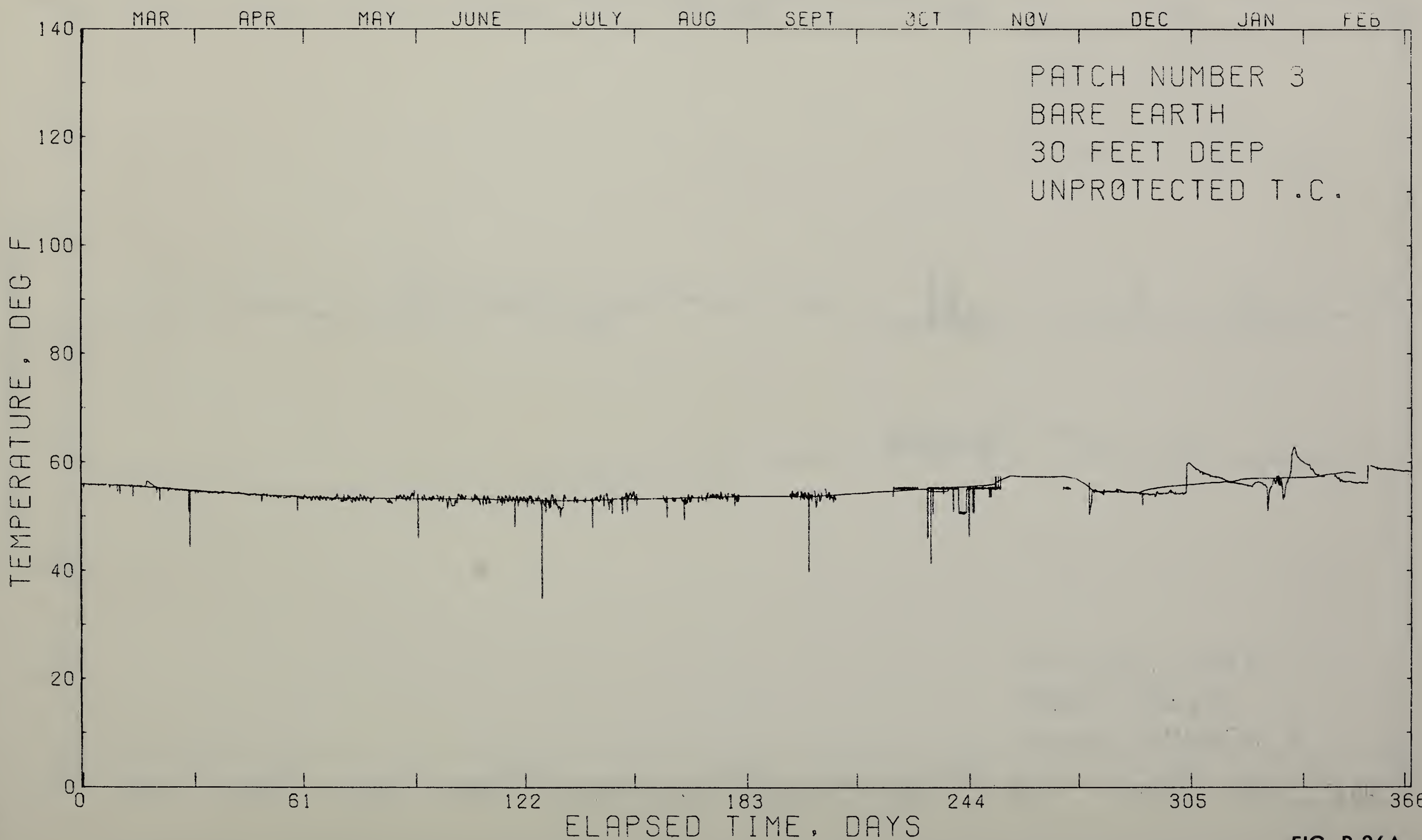

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 3
BARE EARTH
30 FEET DEEP
UNPROTECTED T.C.
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-36A

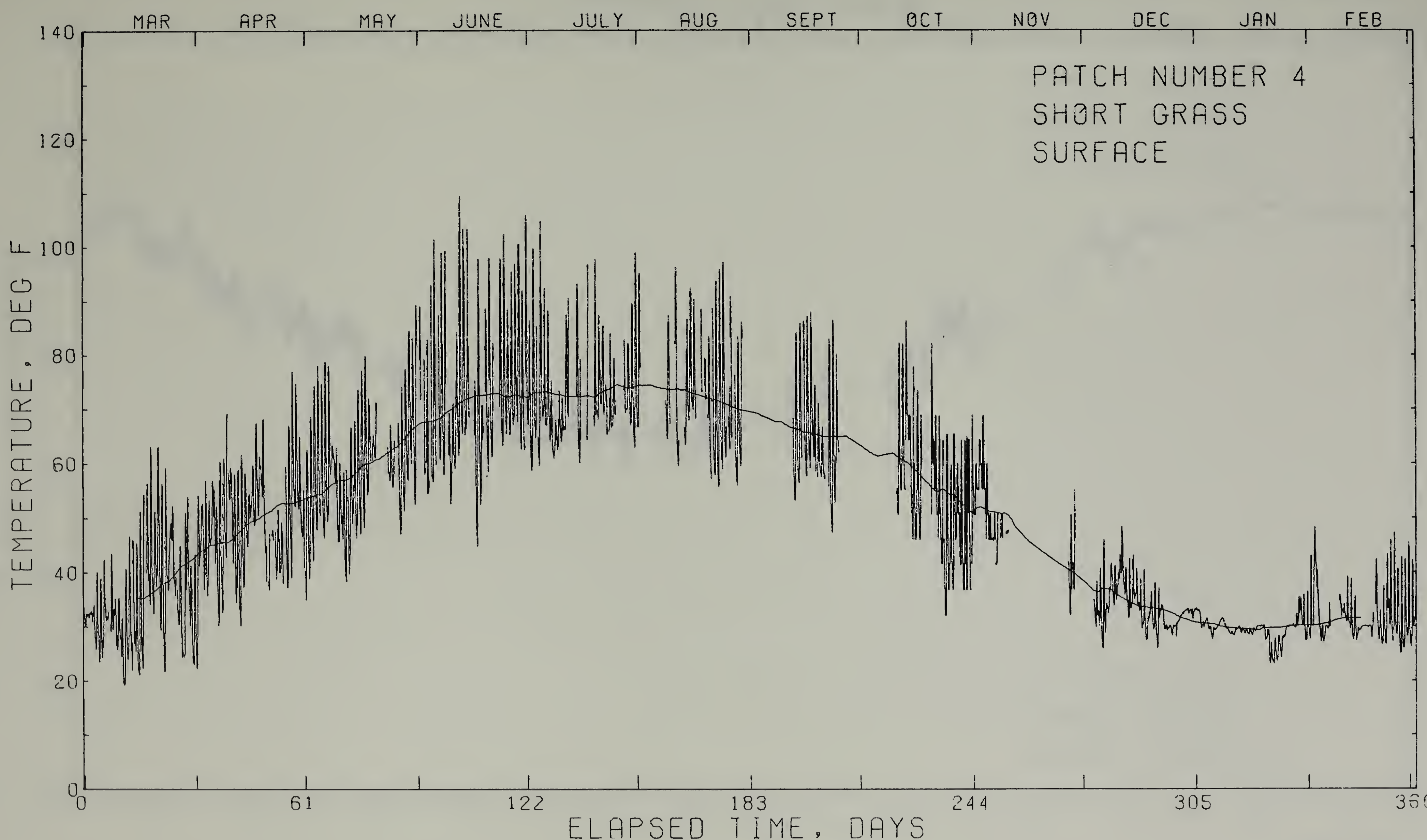

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 4
SHORT GRASS
SURFACE
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-37

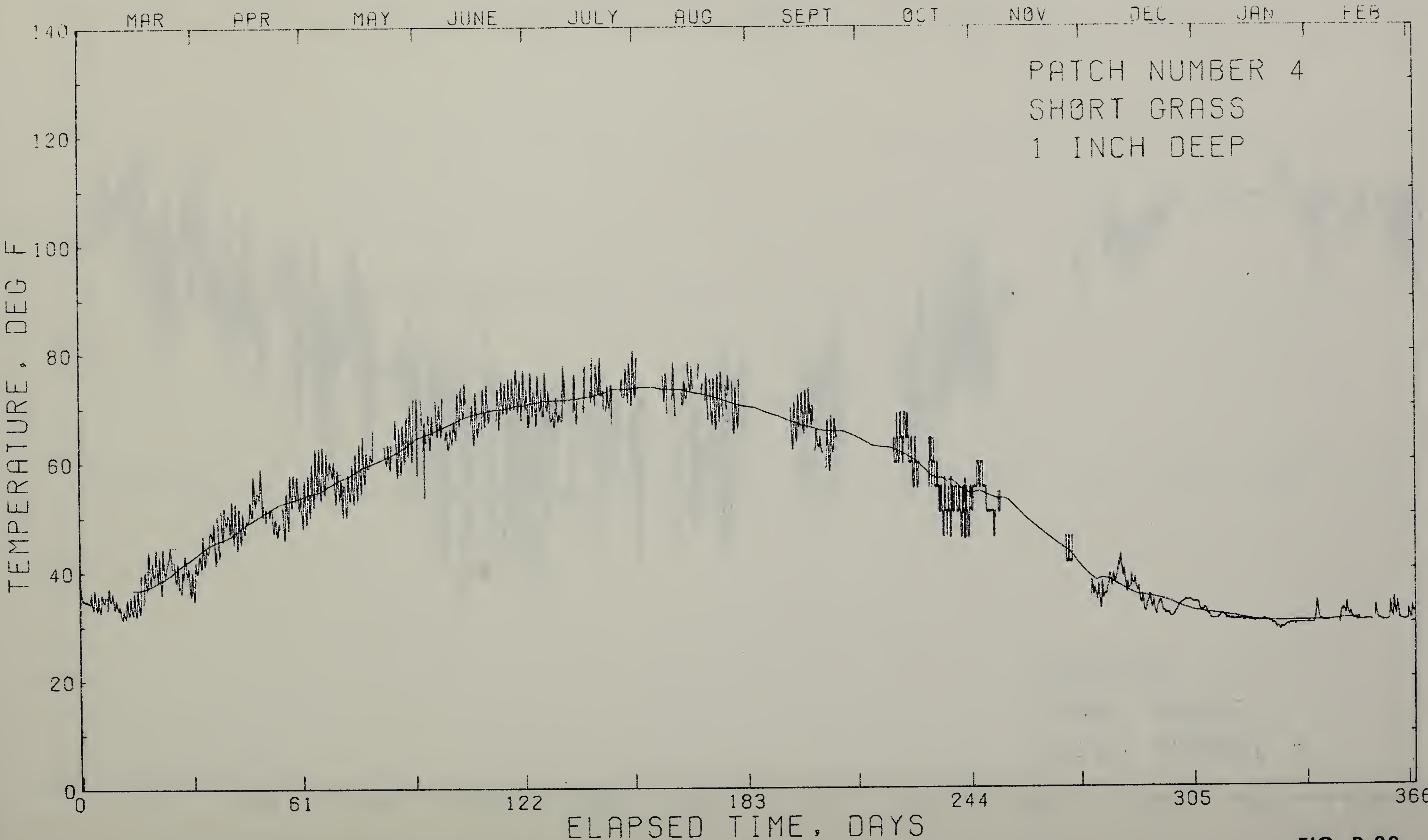

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 4
SHORT GRASS
1 INCH DEEP
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-38

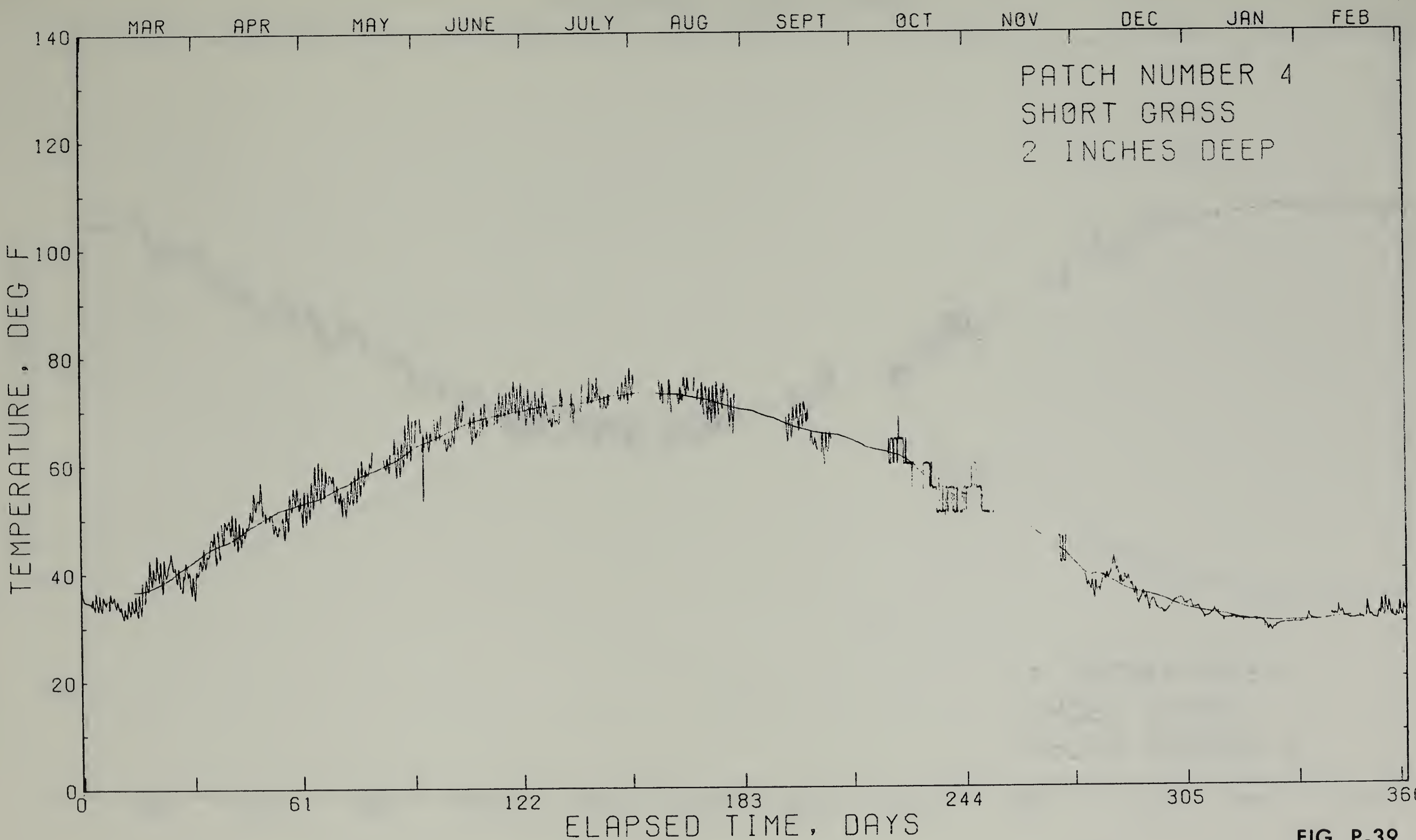
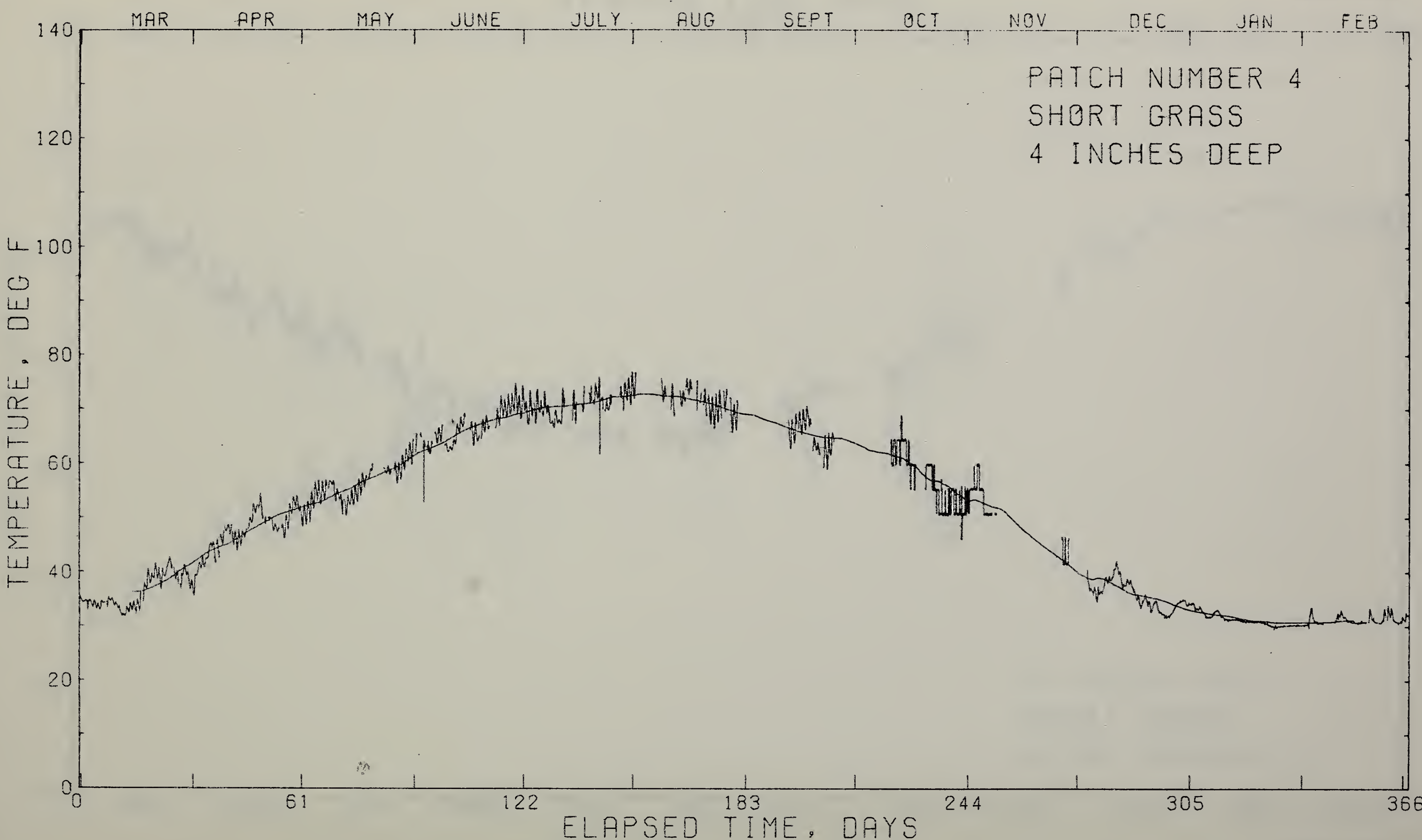

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 4
SHORT GRASS
2 INCHES DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-39



PATCH NUMBER 4
SHORT GRASS
4 INCHES DEEP
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-40

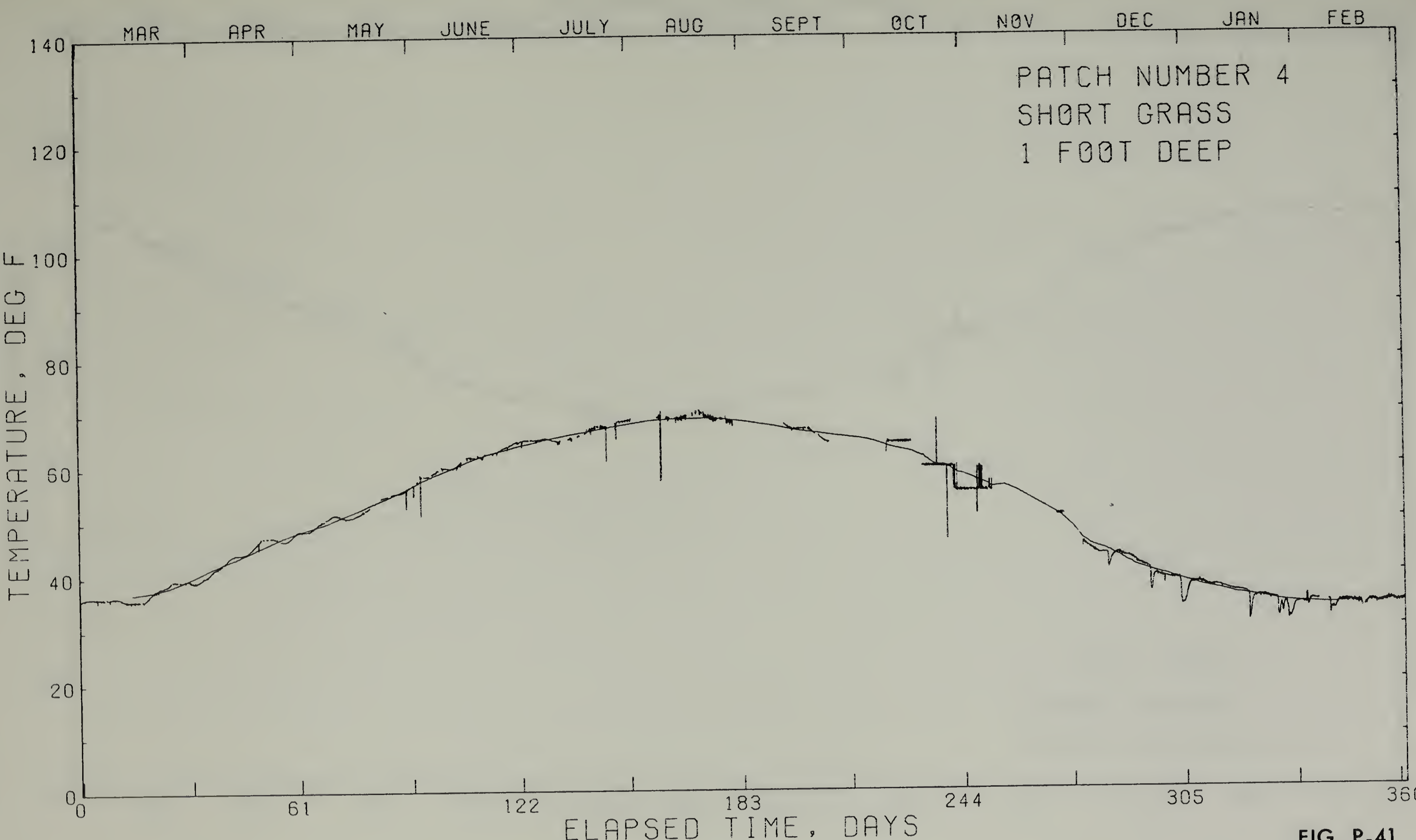

PATCH NUMBER 4
SHORT GRASS
1 FOOT DEEP
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
360
ELAPSED TIME, DAYS

FIG. P-41

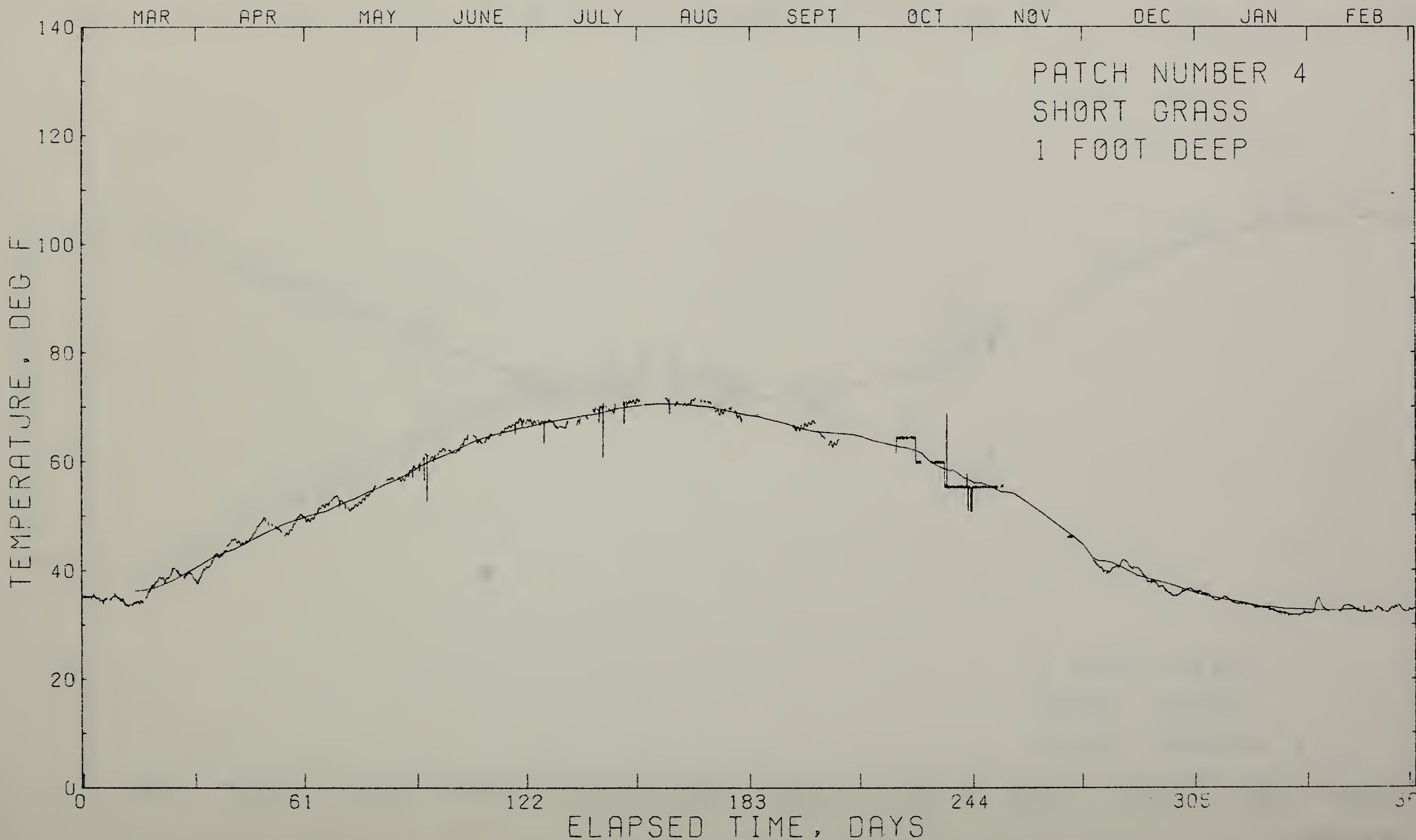
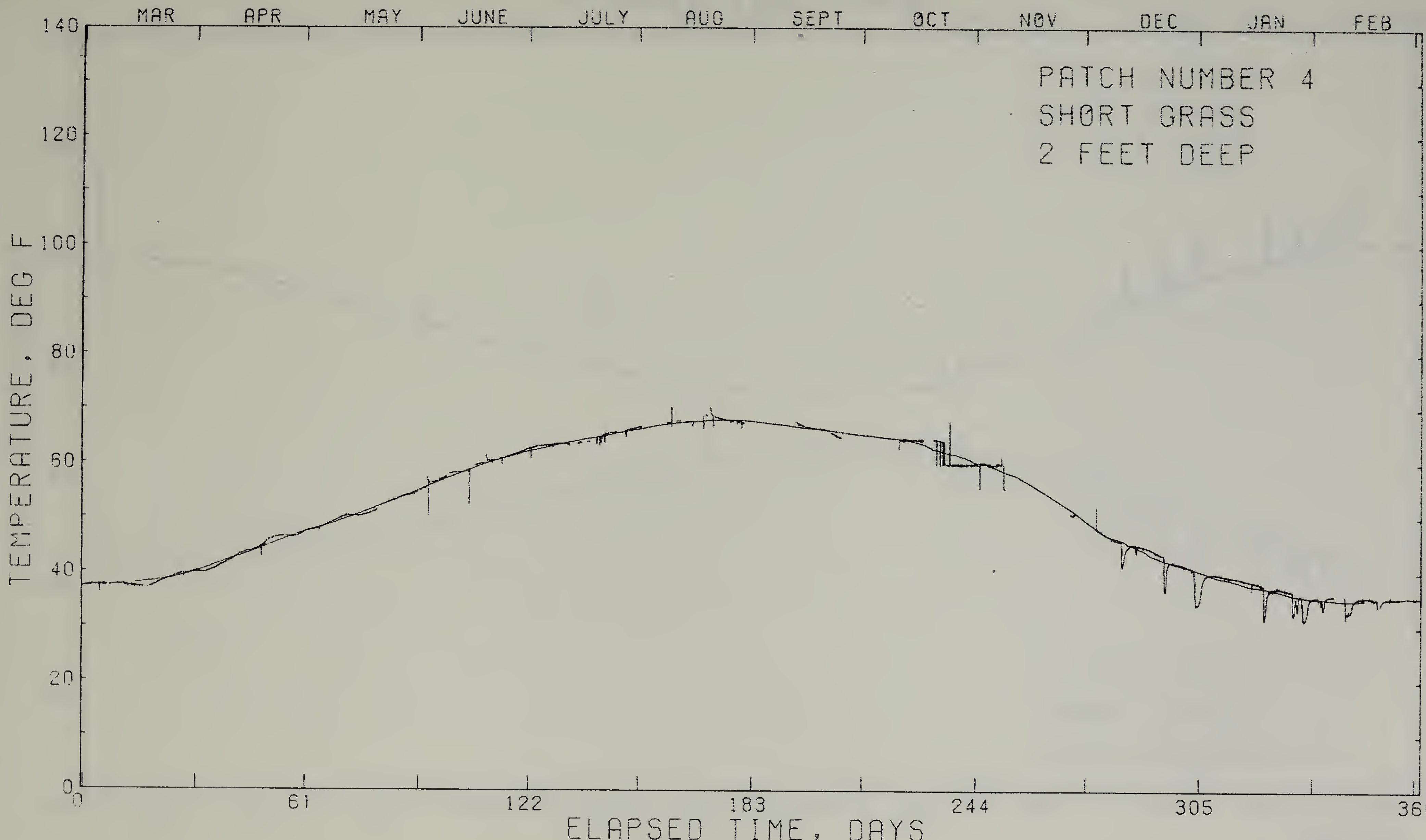
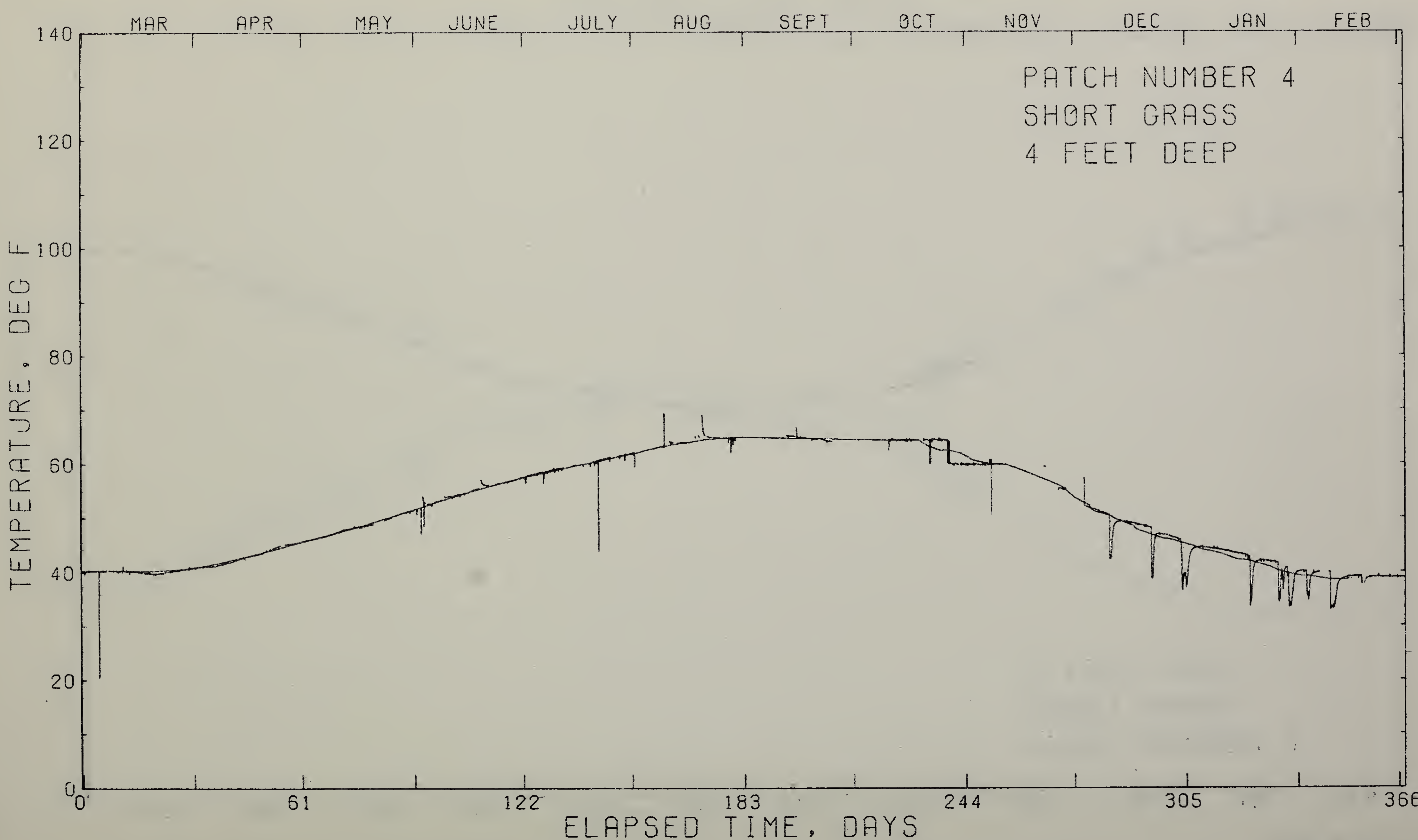

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 4
SHORT GRASS
1 FOOT DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
ELAPSED TIME, DAYS

FIG. P-42



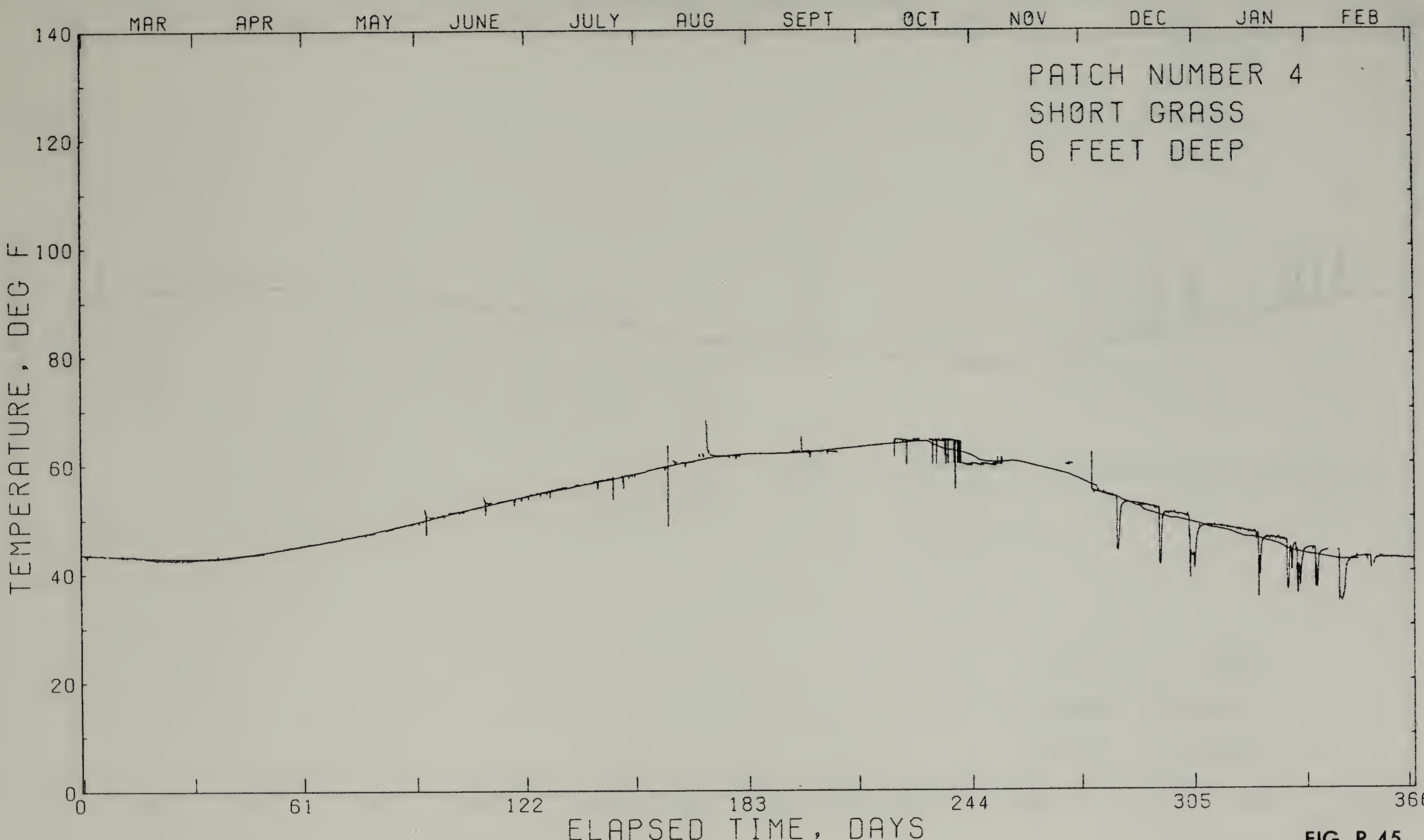
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 4
SHORT GRASS
2 FEET DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-43



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 4
SHORT GRASS
4 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-44



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 4
SHORT GRASS
6 FEET DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-45

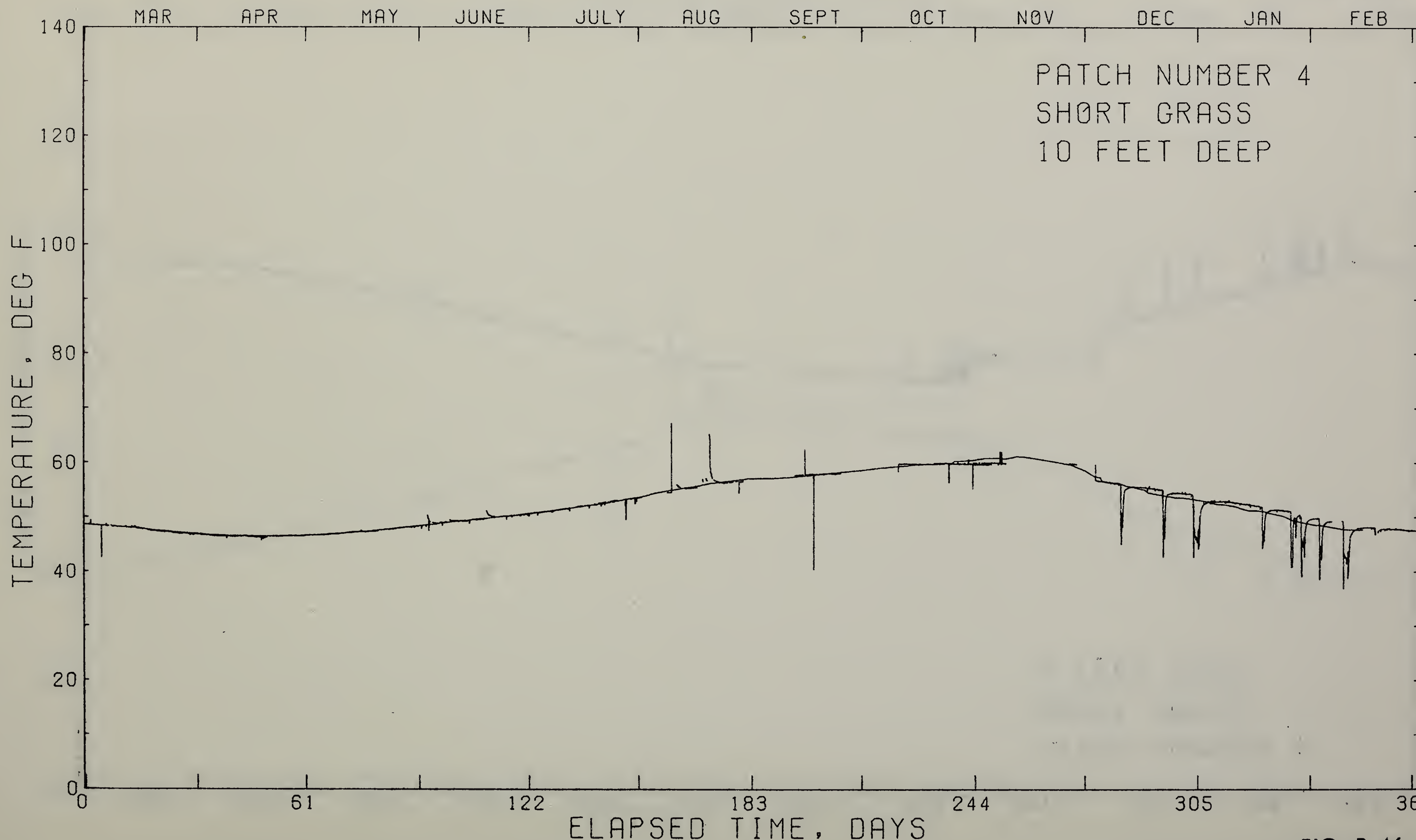
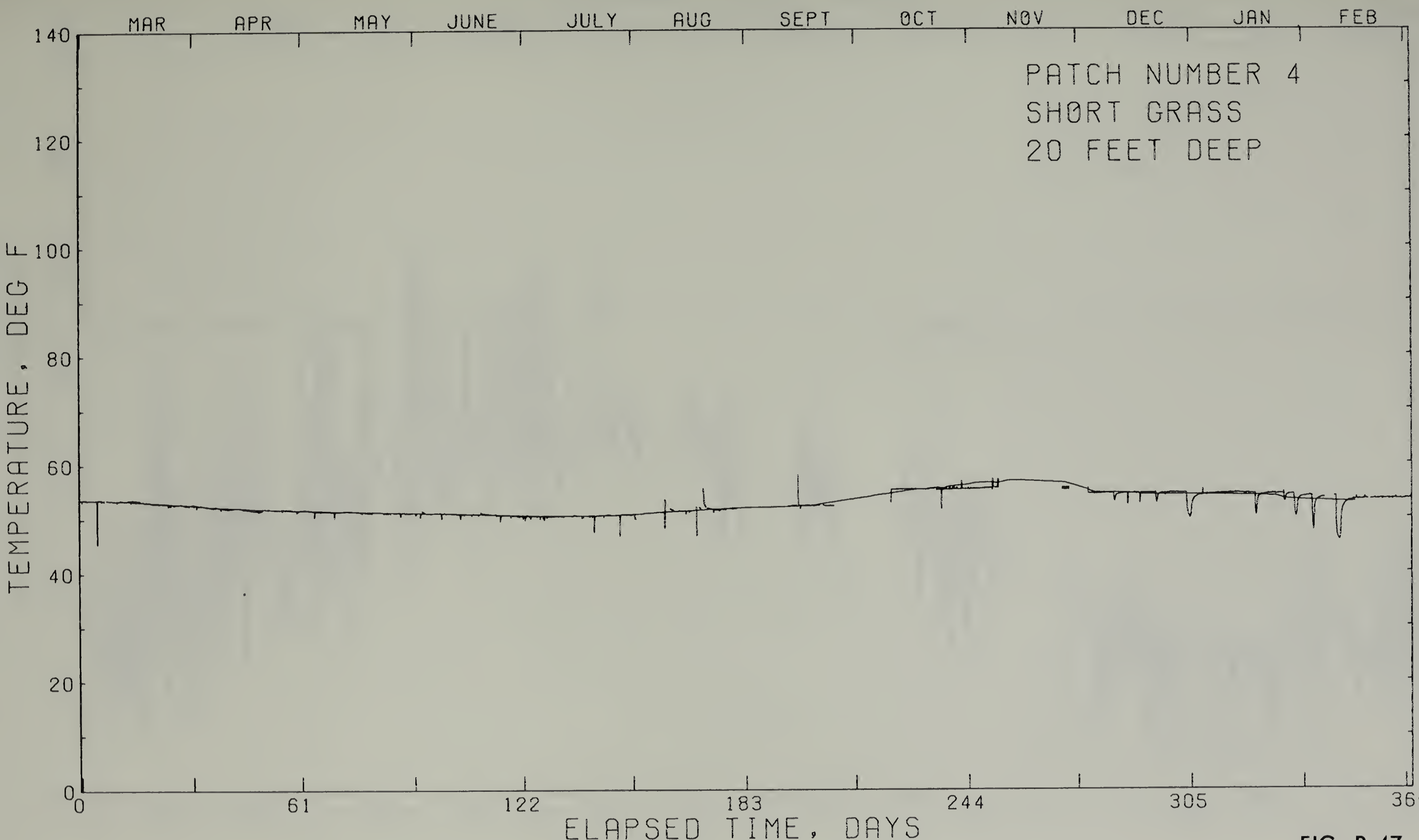
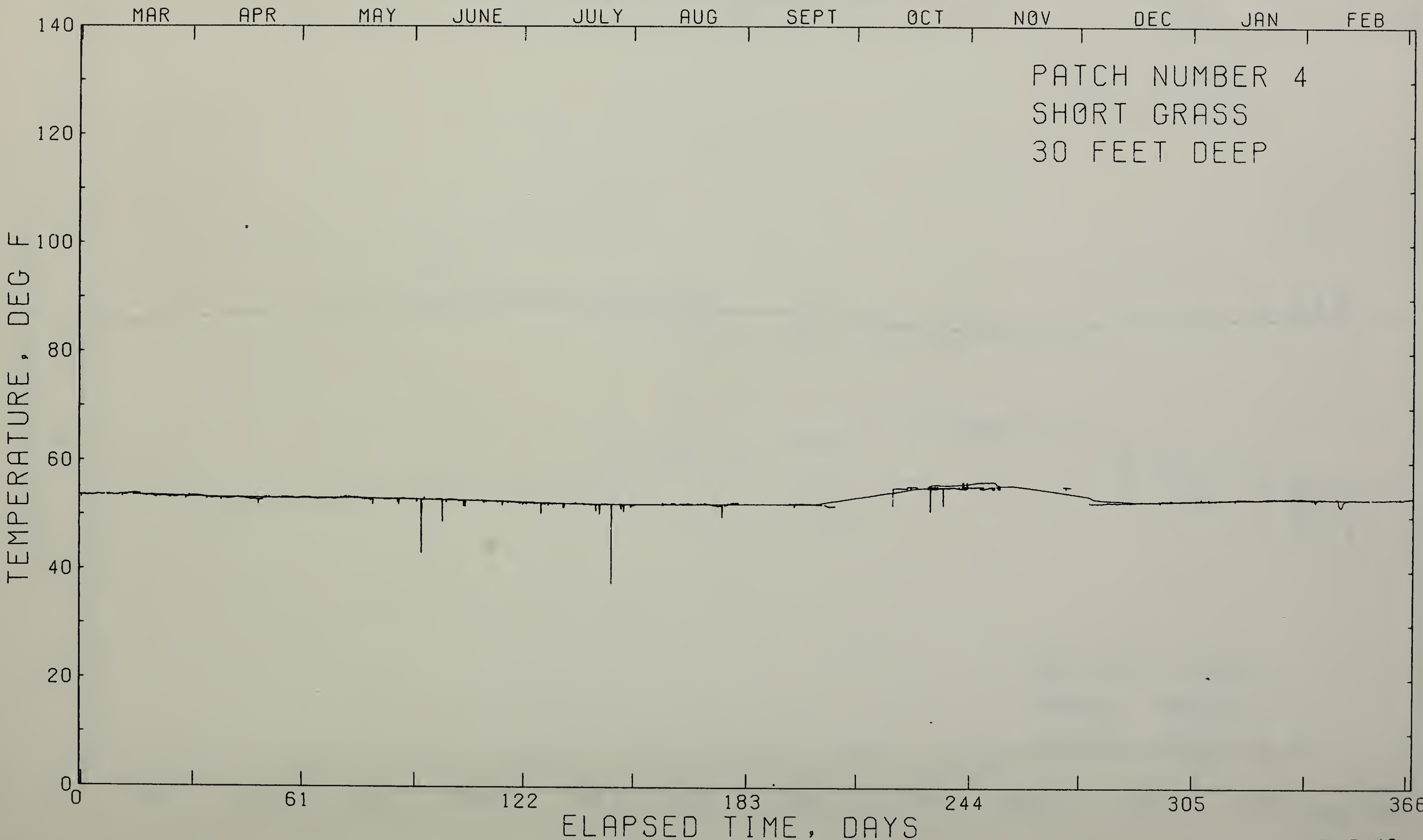

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 4
SHORT GRASS
10 FEET DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-46



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 4
SHORT GRASS
20 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-47



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 4
SHORT GRASS
30 FEET DEEP
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-48

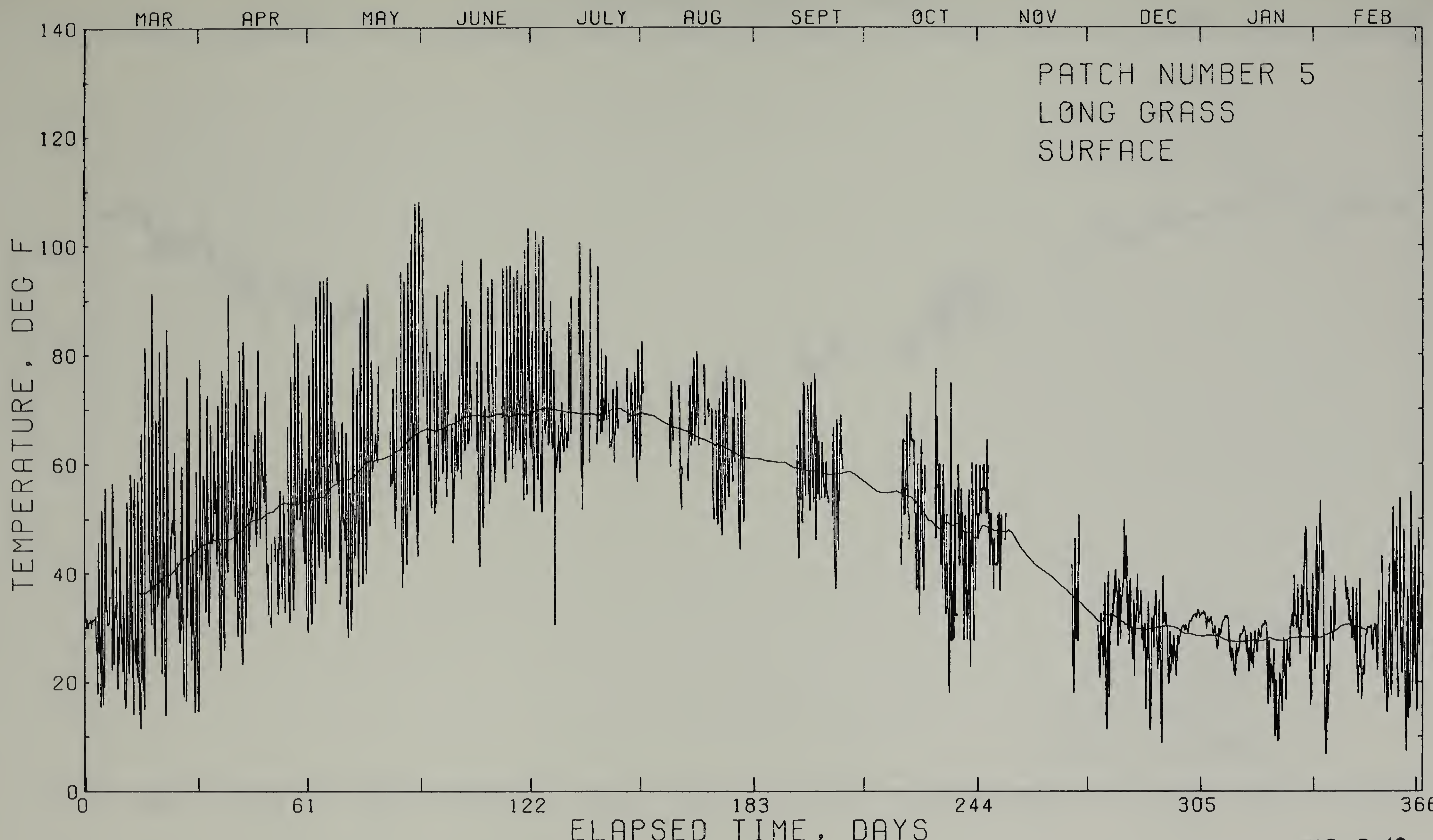
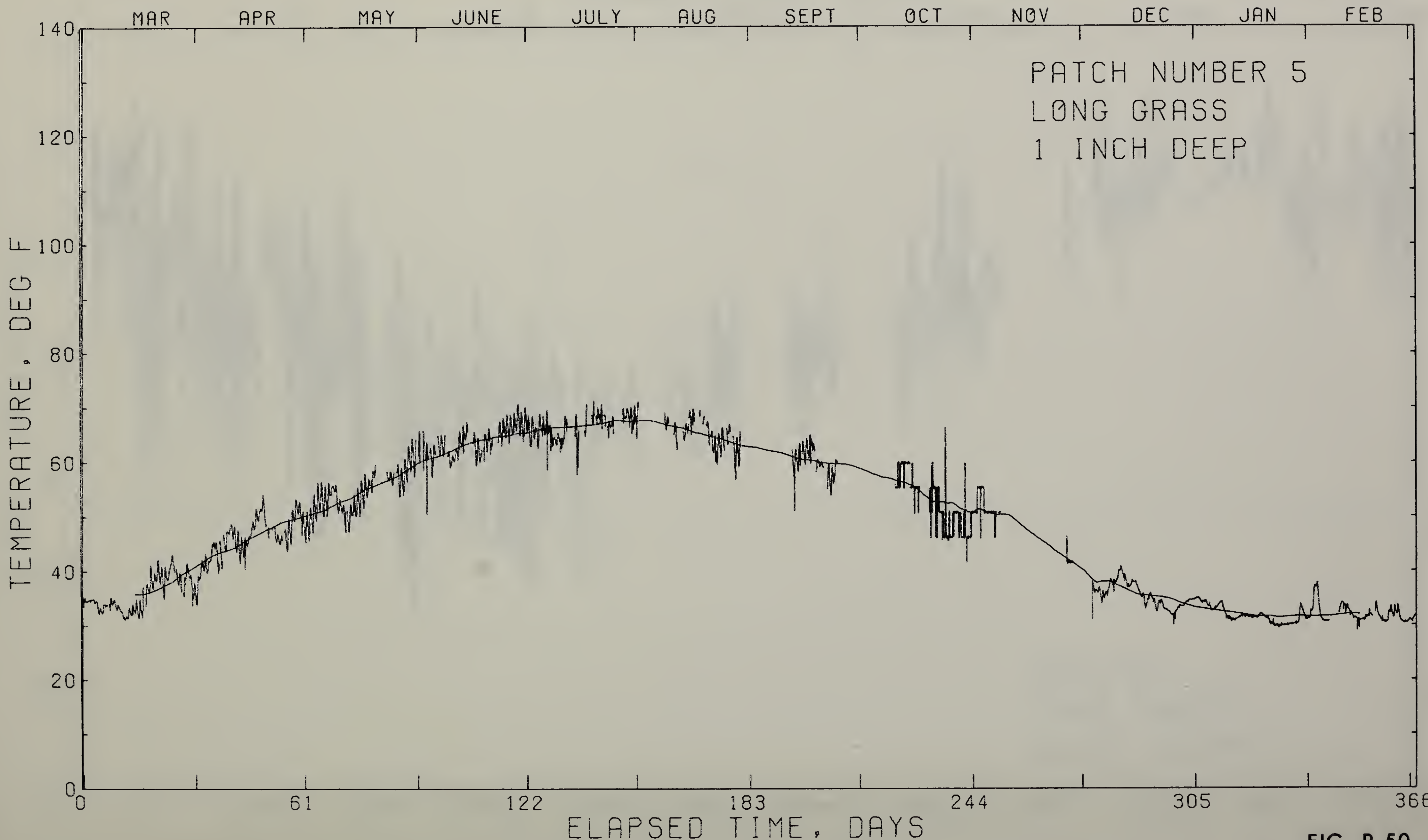

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 5
LONG GRASS
SURFACE
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-49



PATCH NUMBER 5
LØNG GRASS
1 INCH DEEP
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
ØCT
NØV
DEC
JAN
FEB
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-50

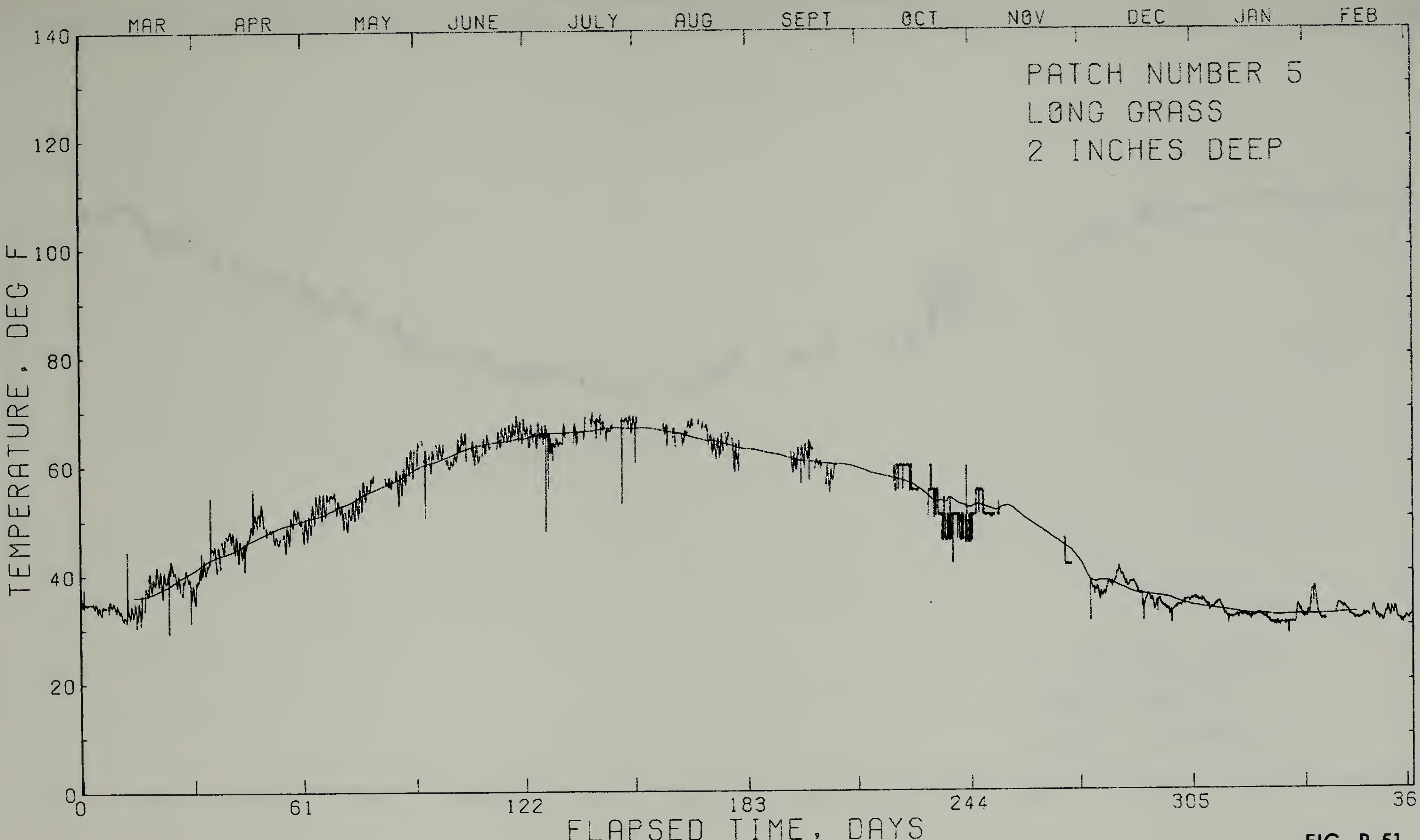
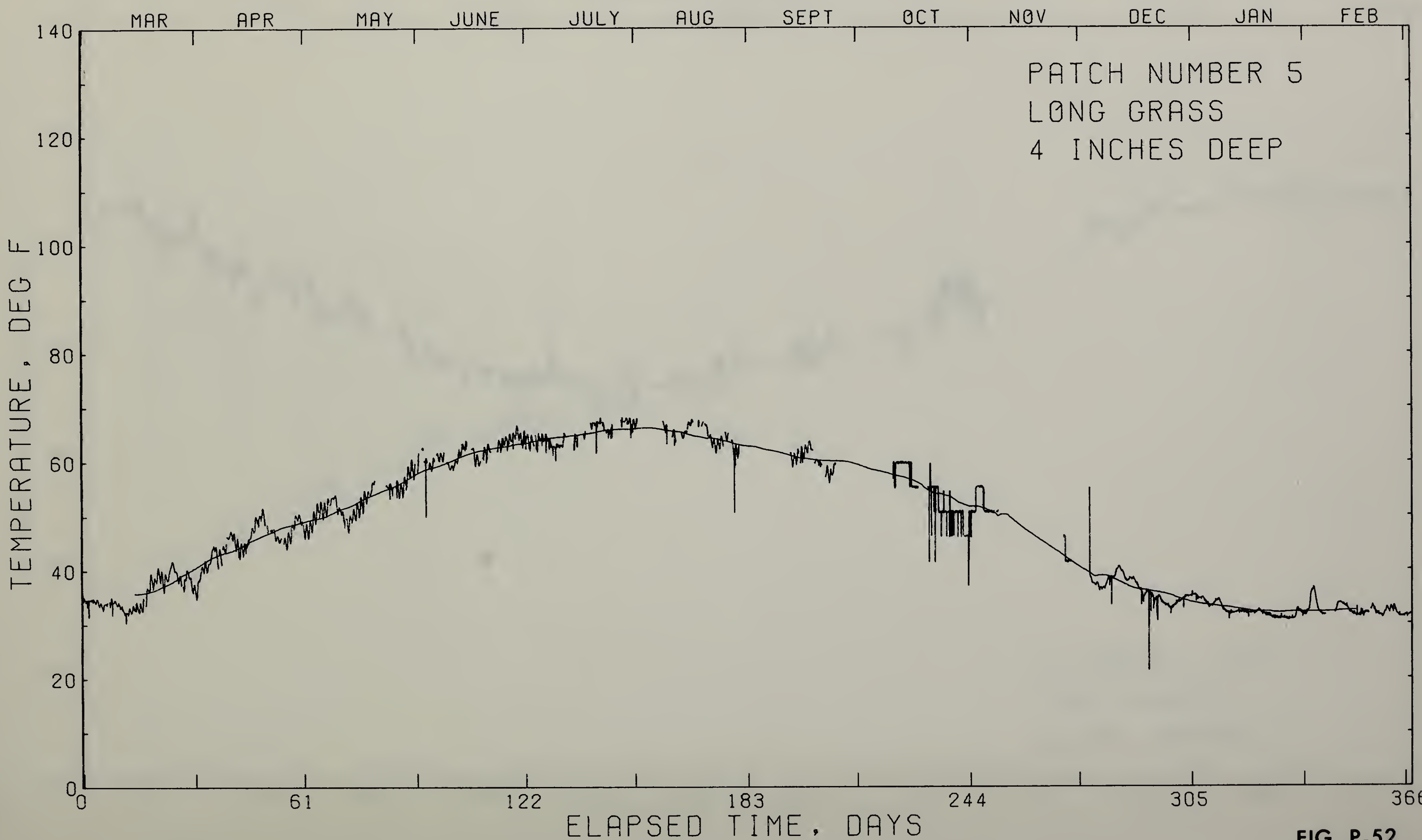

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 5
LONG GRASS
2 INCHES DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-51



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 5
LONG GRASS
4 INCHES DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-52

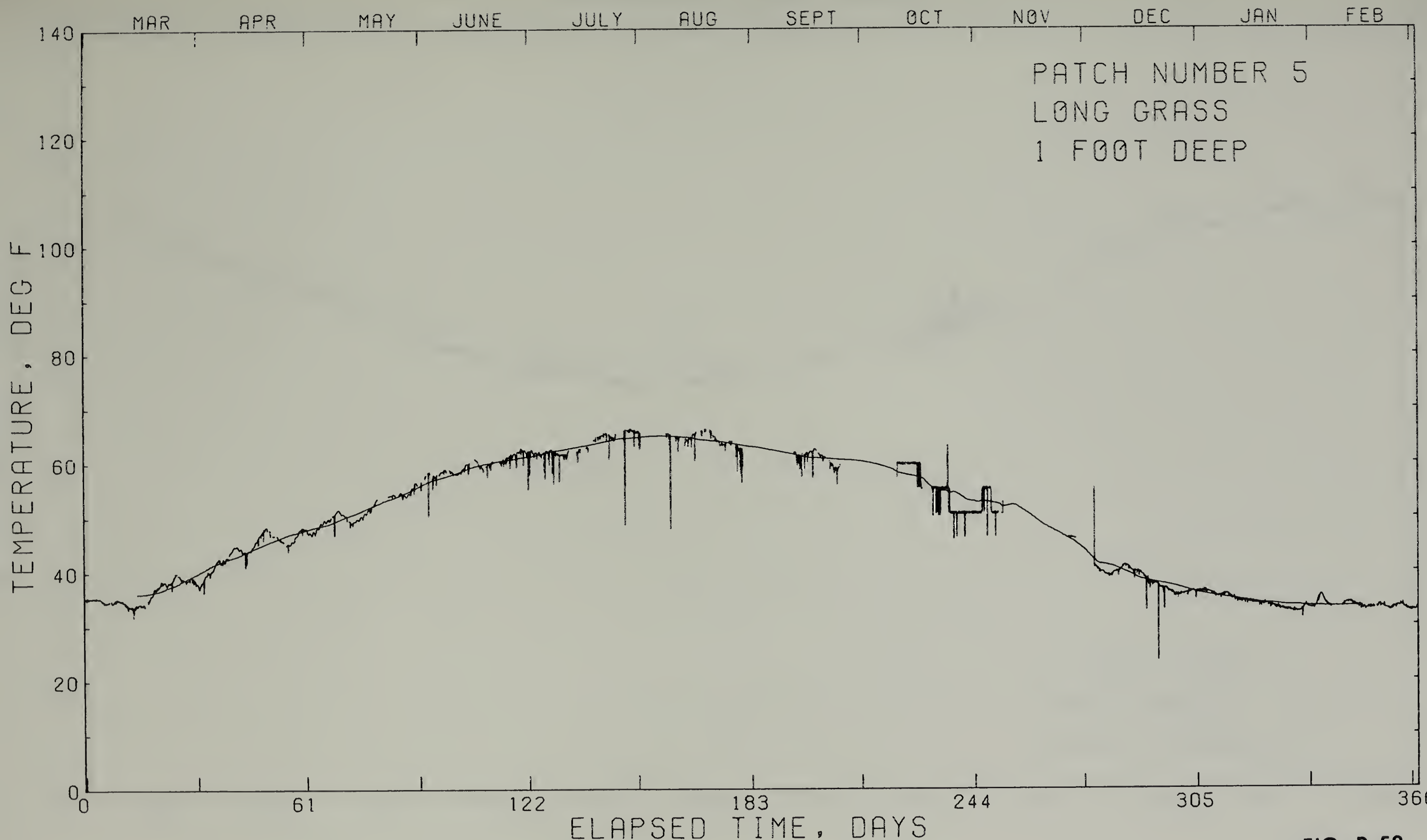
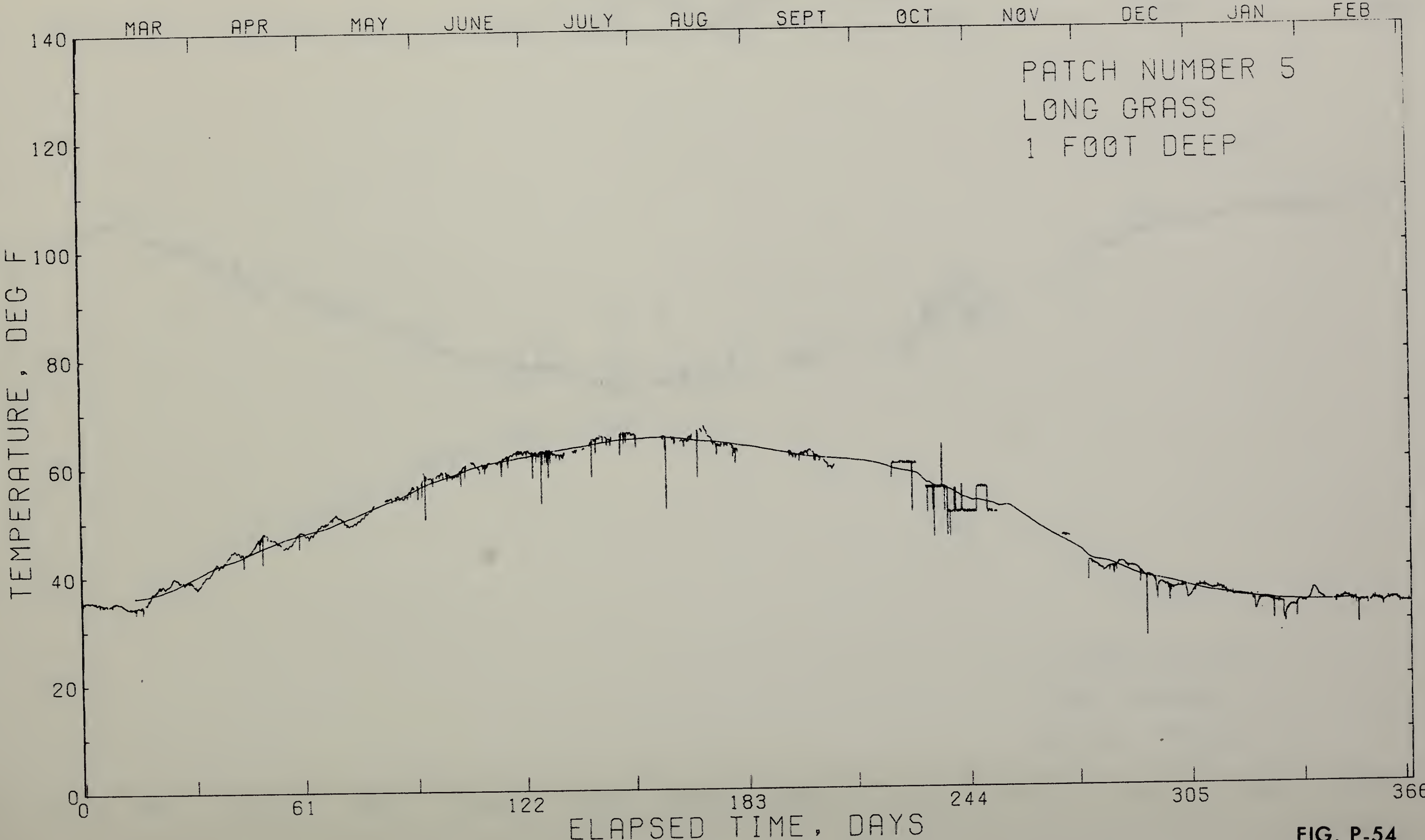
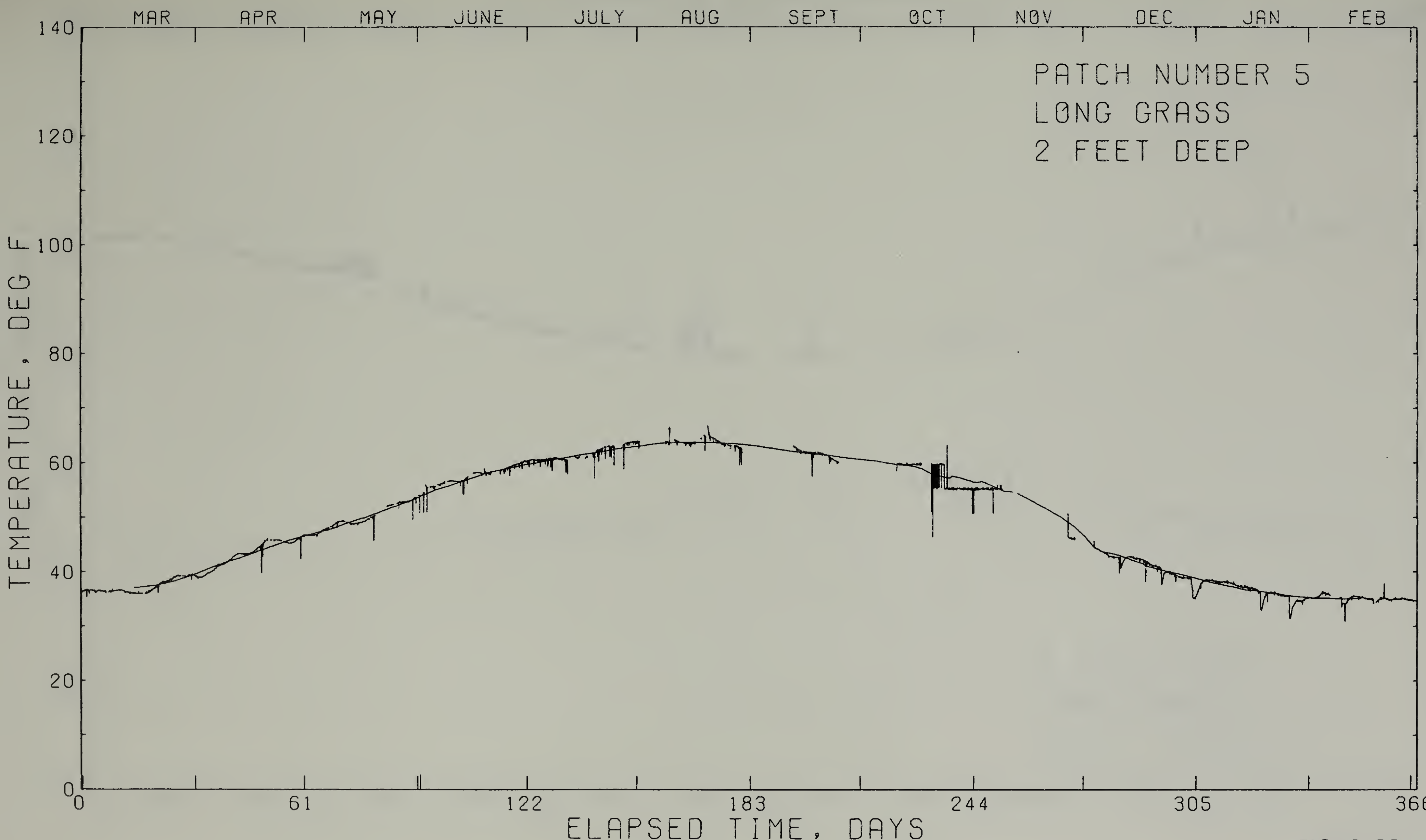

PATCH NUMBER 5
LØNG GRASS
1 FØØT DEEP
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
ØCT
NØV
DEC
JAN
FEB
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-53



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 5
LONG GRASS
1 FOOT DEEP
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-54



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
ØCT
NØV
DEC
JAN
FEB
PATCH NUMBER 5
LØNG GRASS
2 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-55

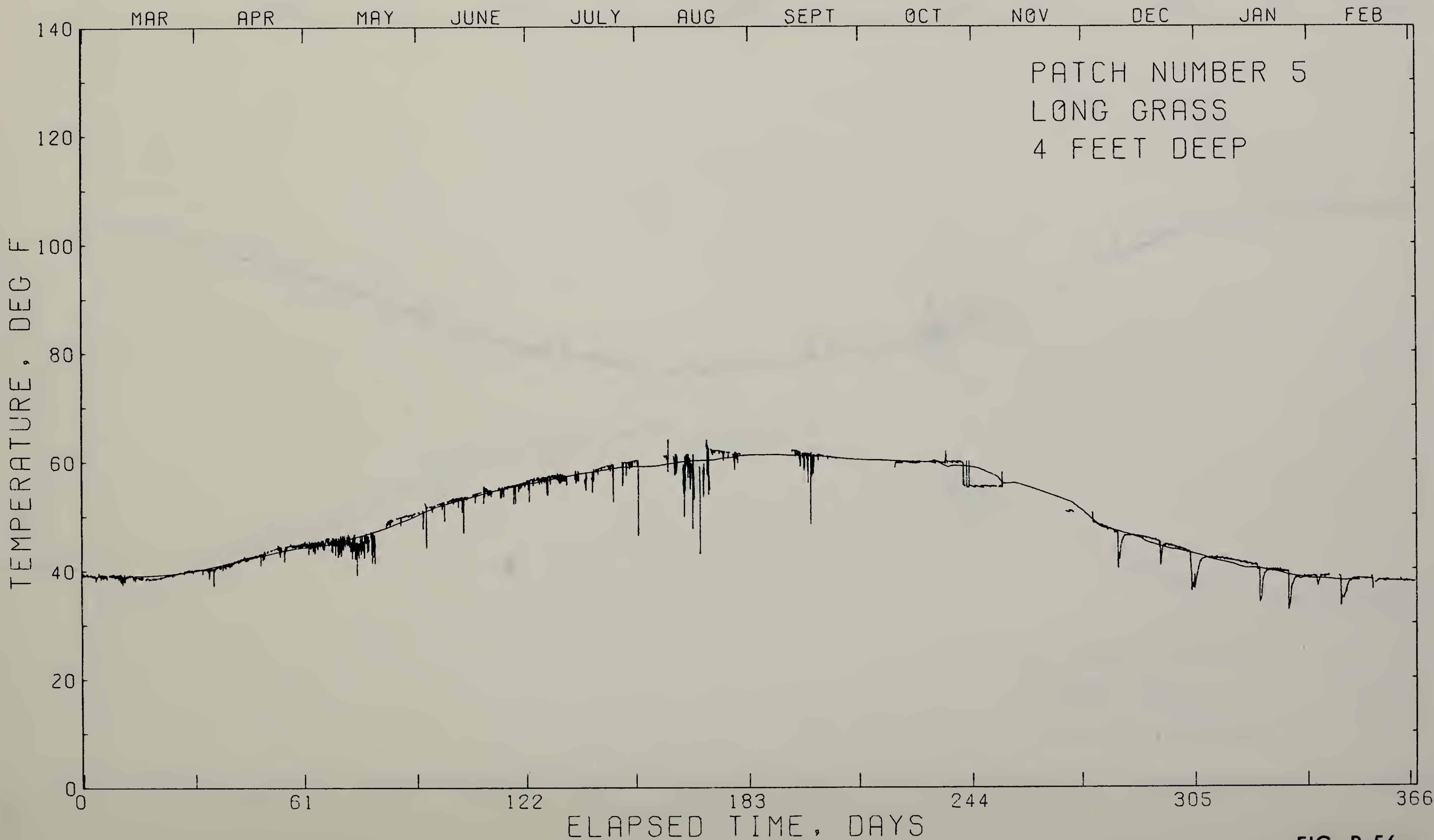
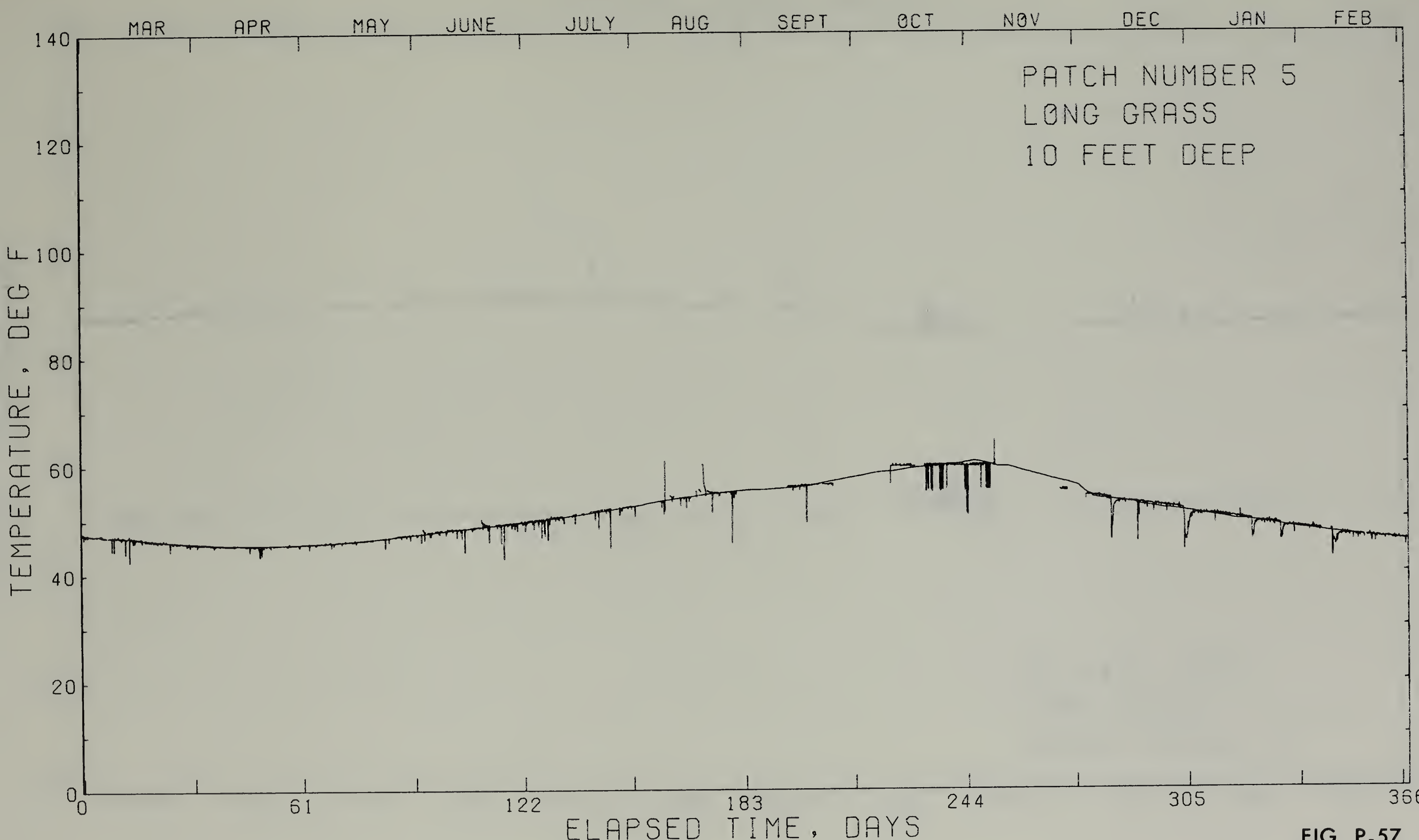
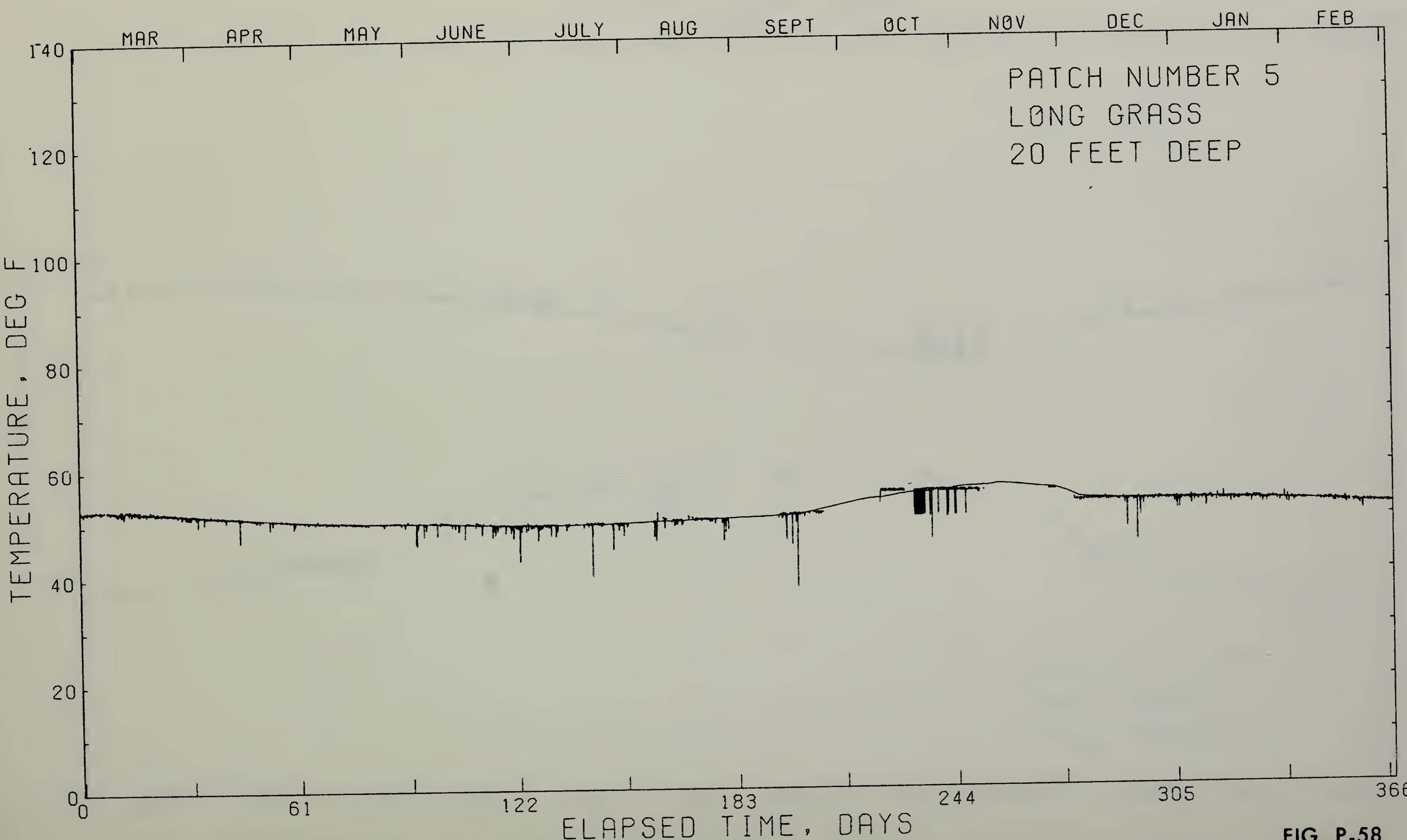

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 5
LONG GRASS
4 FEET DEEP
TEMPERATURE, DEG F
0
20
40
60
80
100
120
140
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-56



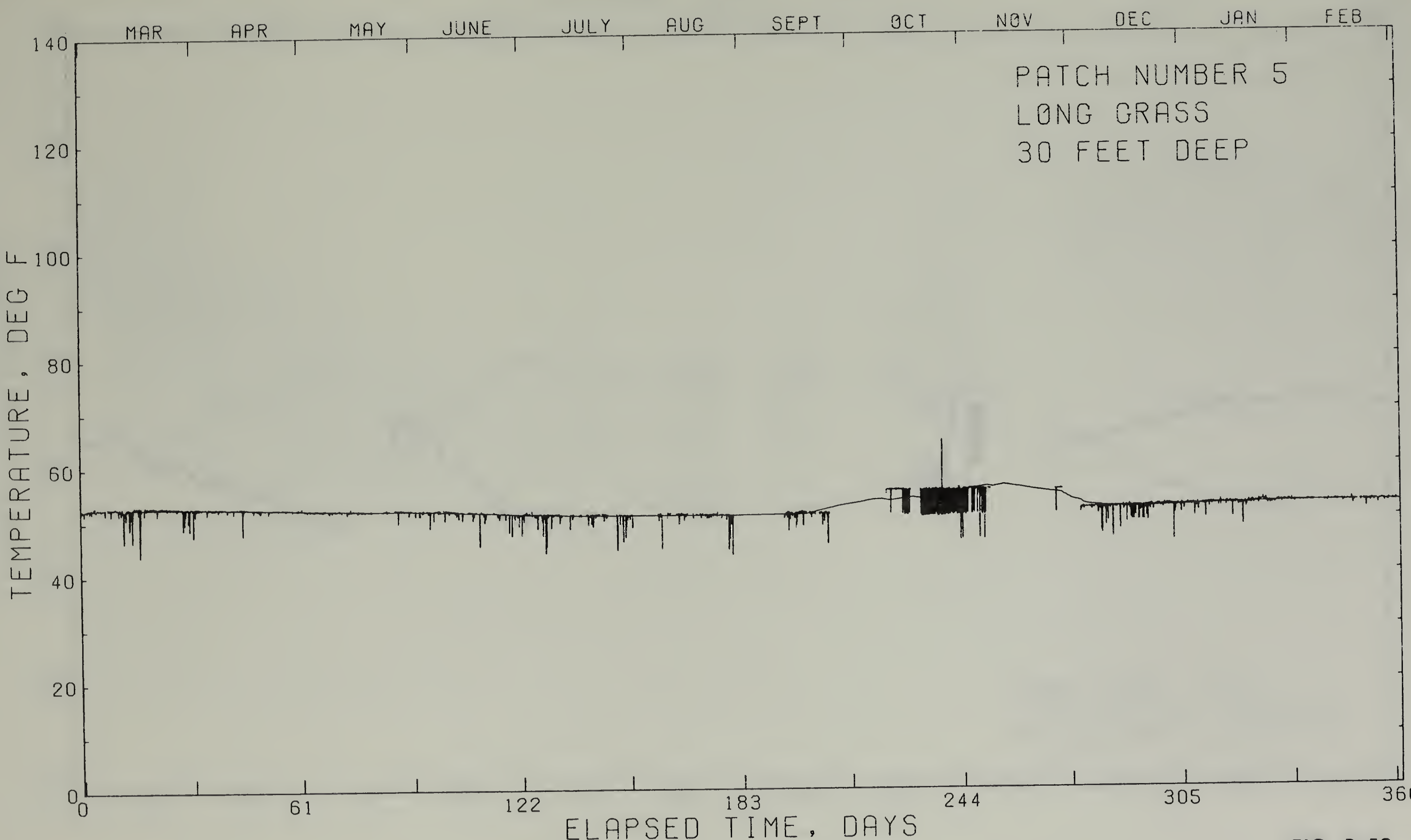
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
ØCT
NØV
DEC
JAN
FEB
PATCH NUMBER 5
LØNG GRASS
10 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-57



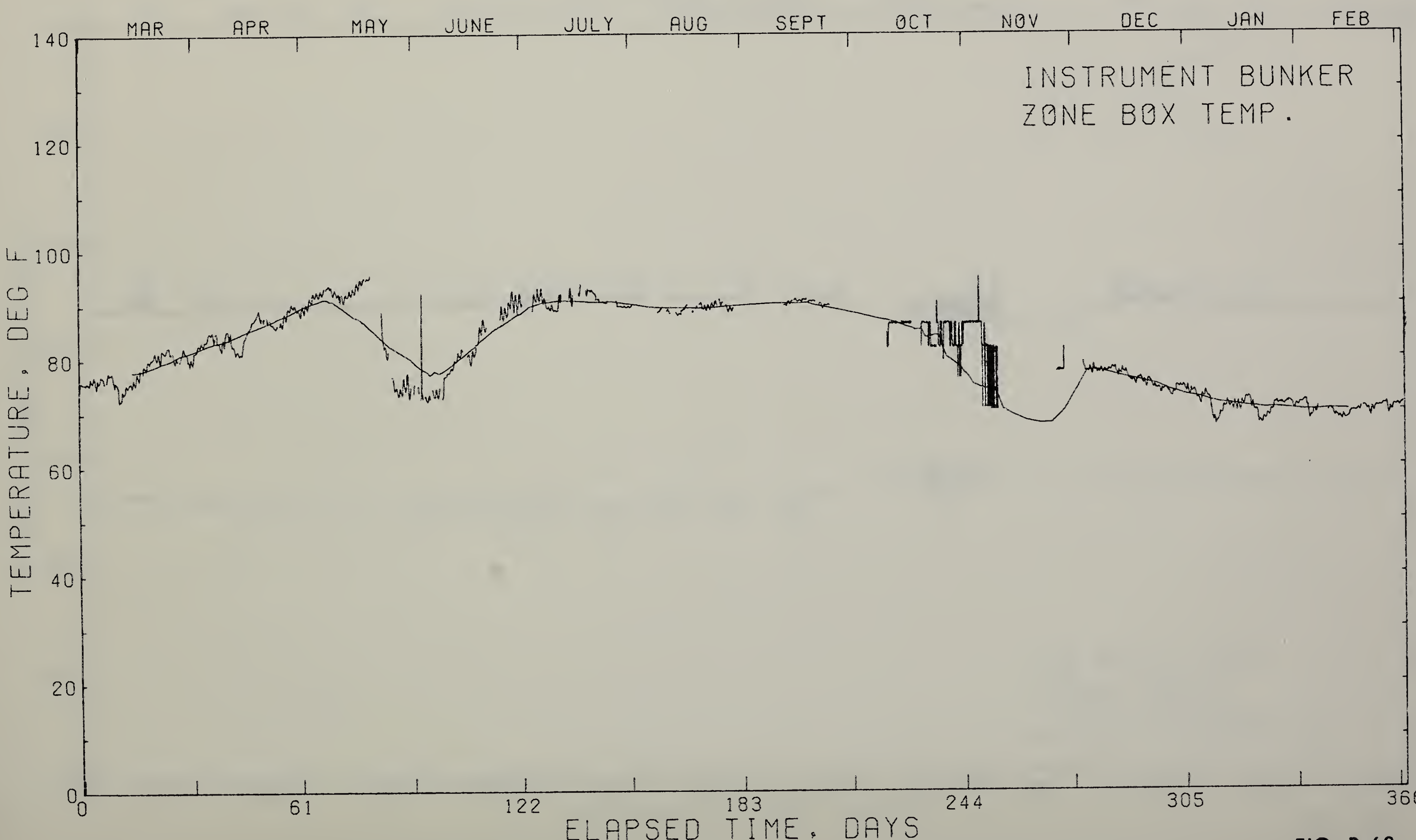
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 5
LONG GRASS
20 FEET DEEP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-58



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
PATCH NUMBER 5
LONG GRASS
30 FEET DEEP
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-59



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
INSTRUMENT BUNKER
ZONE BOX TEMP.
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-60

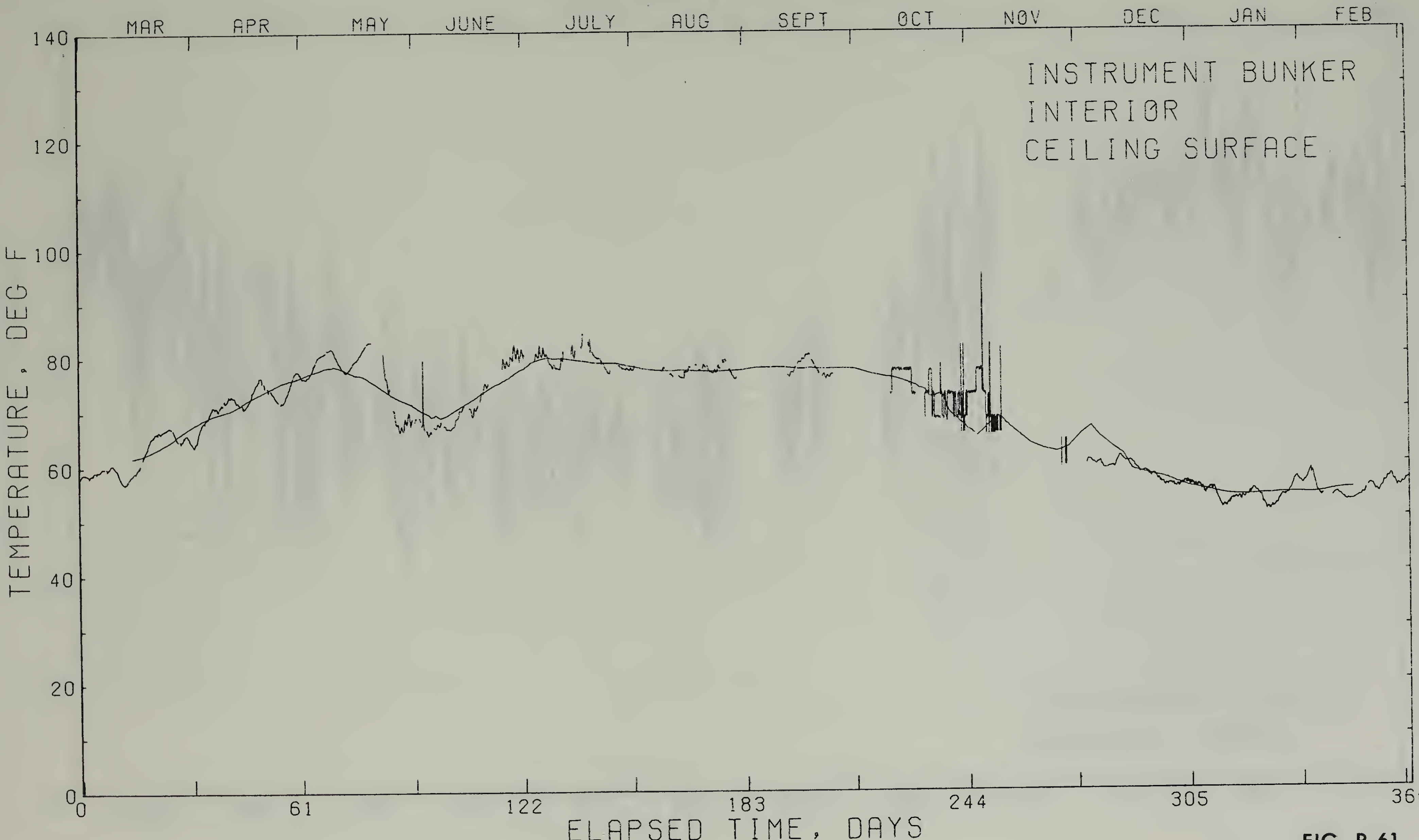

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
INSTRUMENT BUNKER
INTERIØR
CEILING SURFACE
140
120
100
80
60
40
20
0
TEMPERATURE, DEG F
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-61

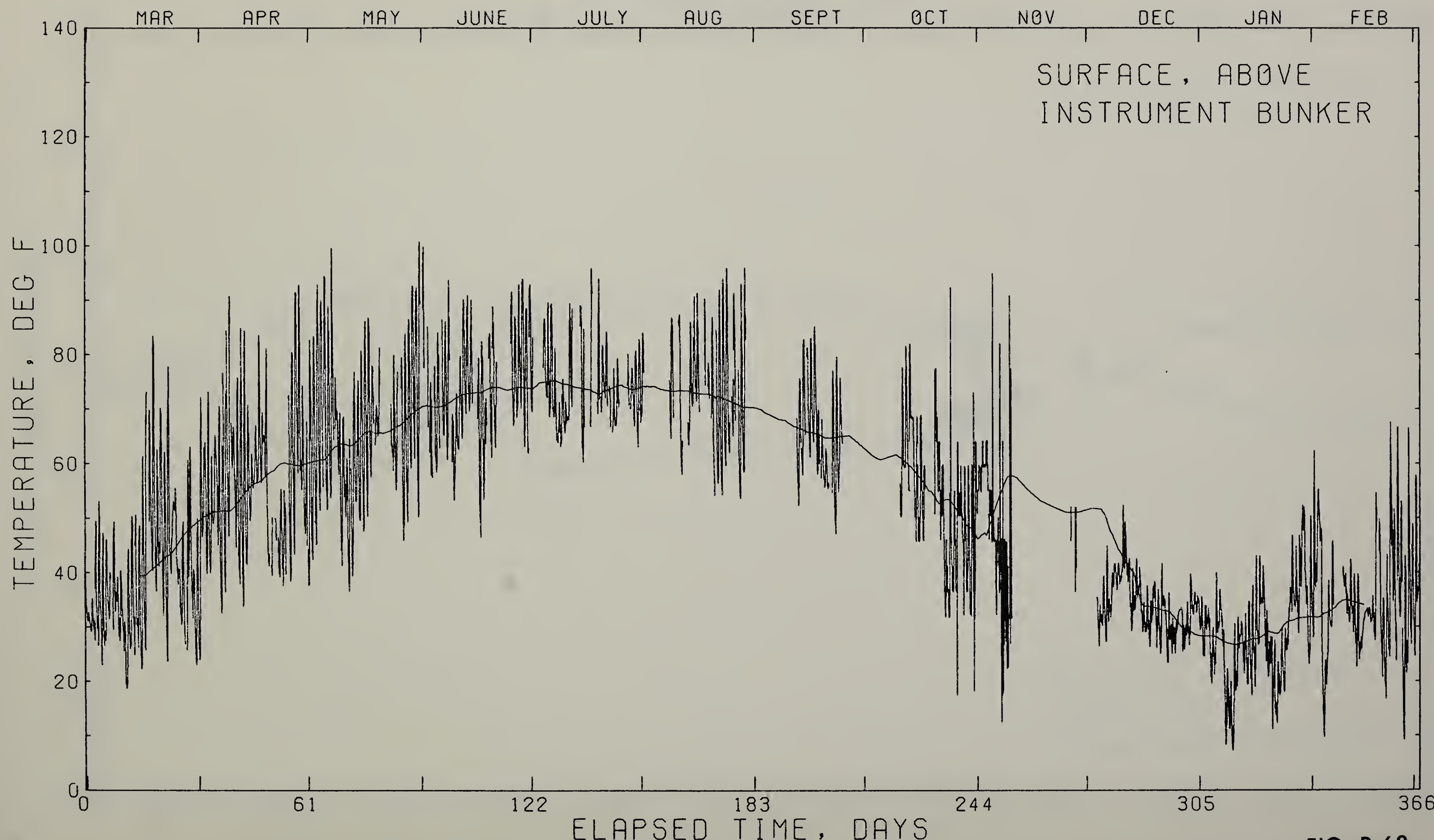

SURFACE, ABOVE
INSTRUMENT BUNKER
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-62

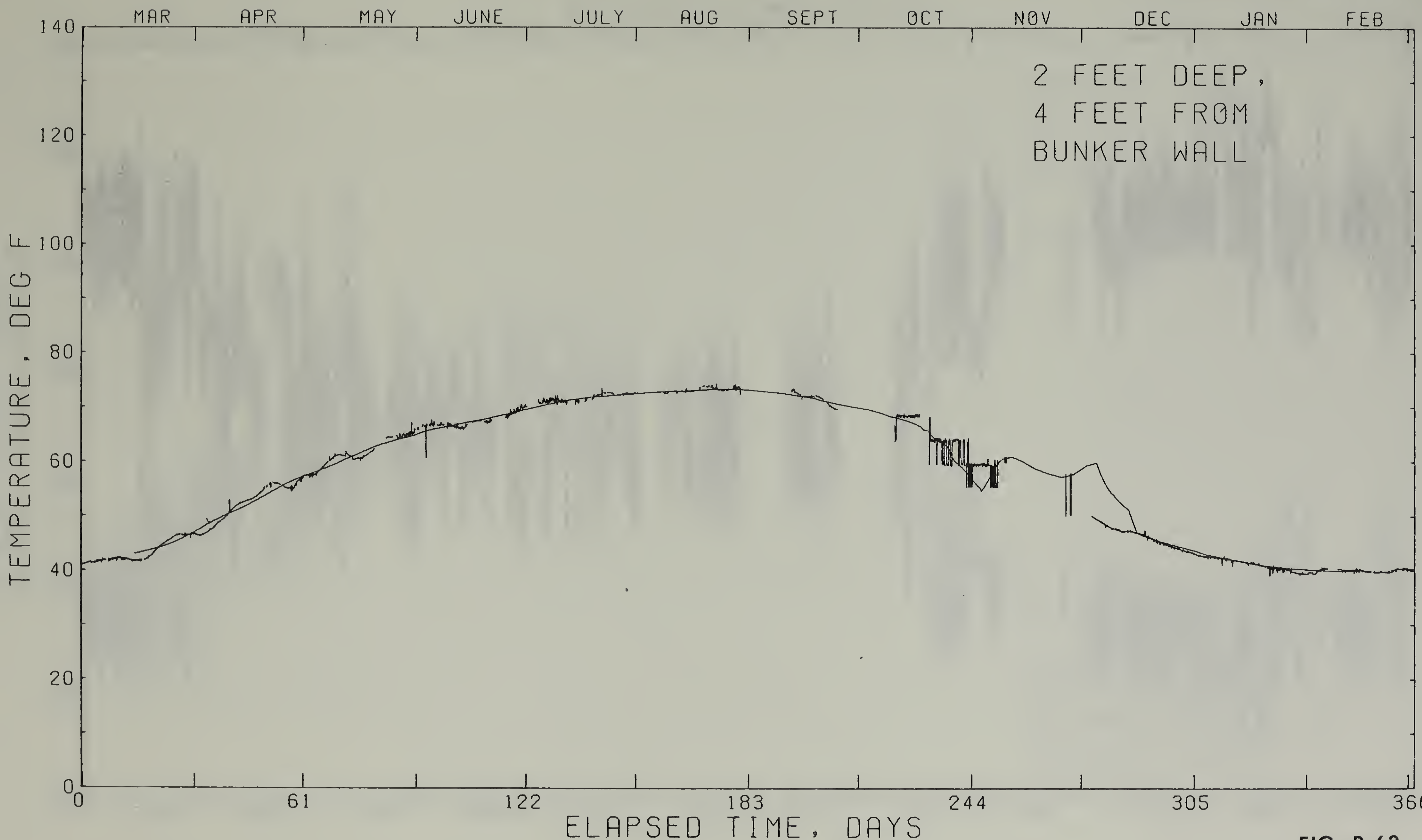

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
2 FEET DEEP,
4 FEET FROM
BUNKER WALL
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-63

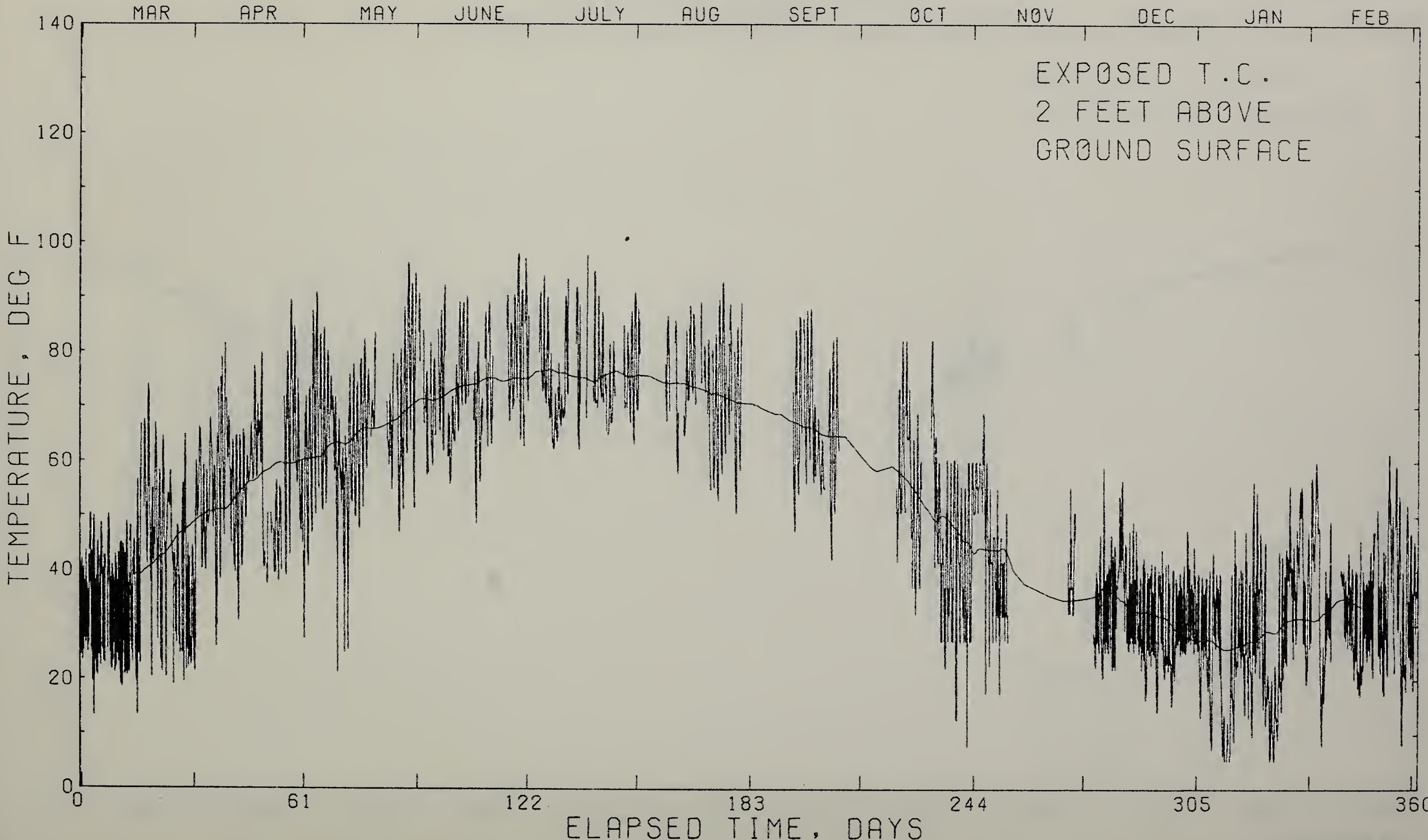
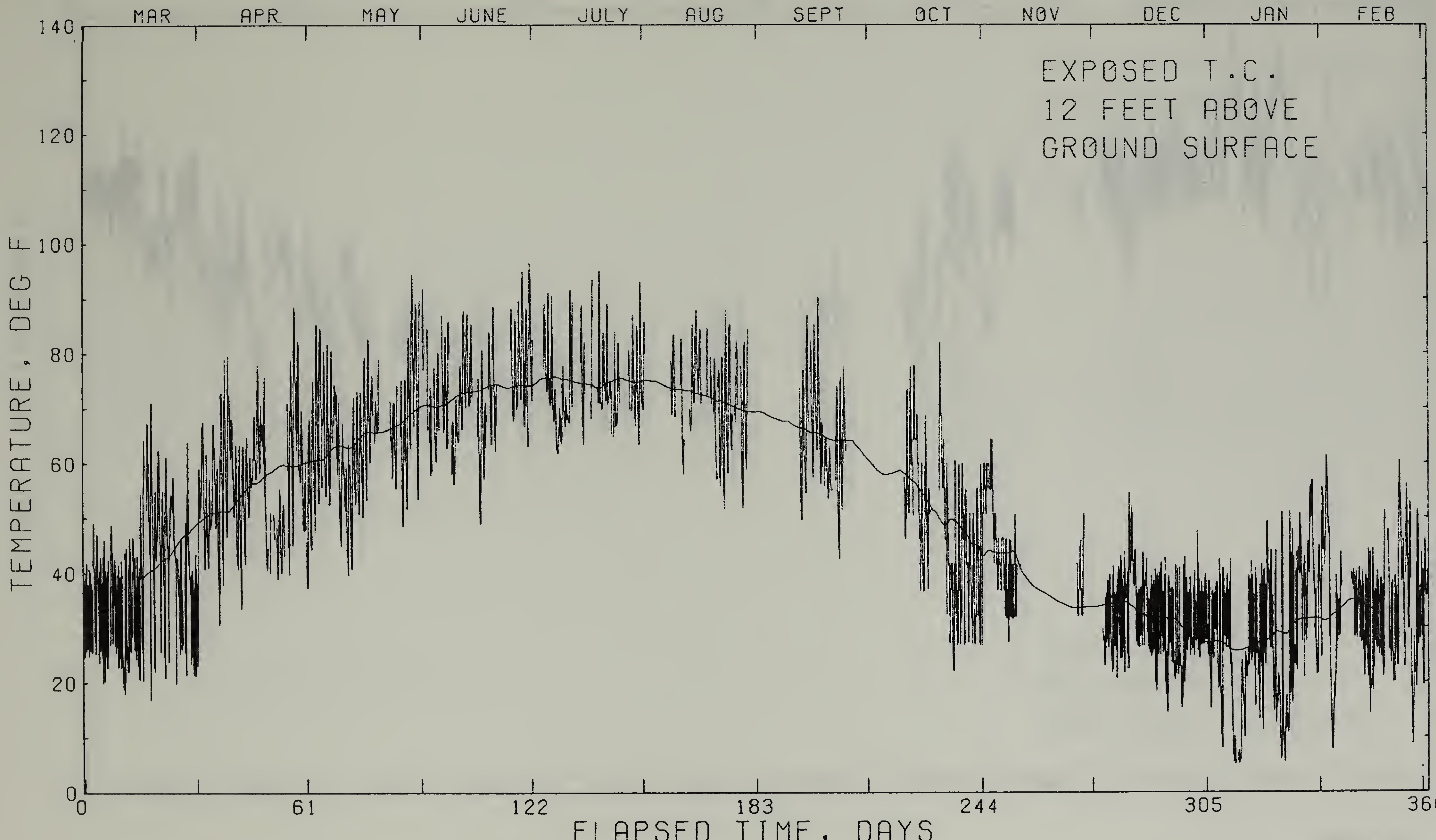

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
EXPOSED T.C.
2 FEET ABOVE
GROUND SURFACE
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
360
ELAPSED TIME, DAYS

FIG. P-64



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
EXPOSED T.C.
12 FEET ABOVE
GROUND SURFACE
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-65

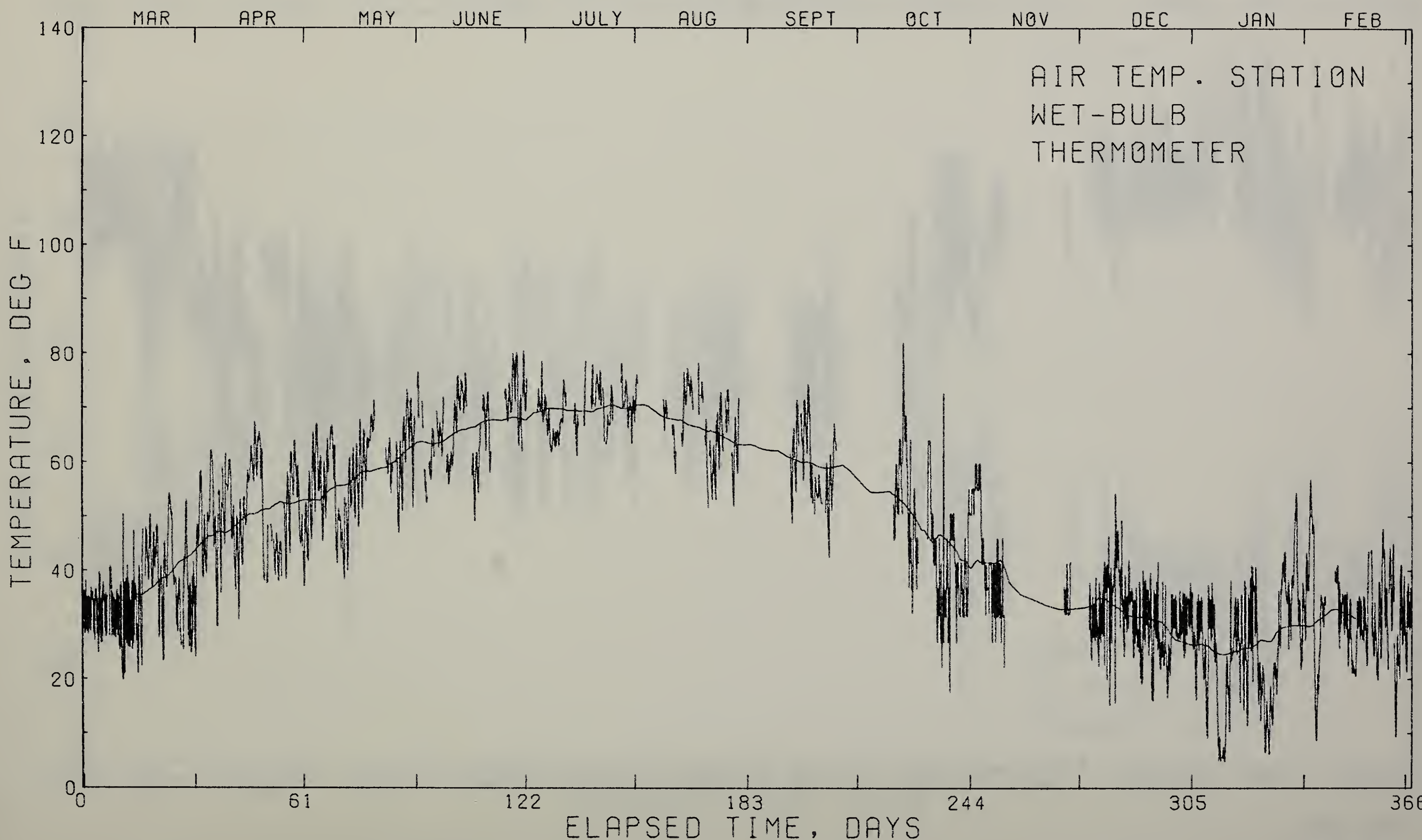

AIR TEMP. STATION
WET-BULB
THERMOMETER
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-66

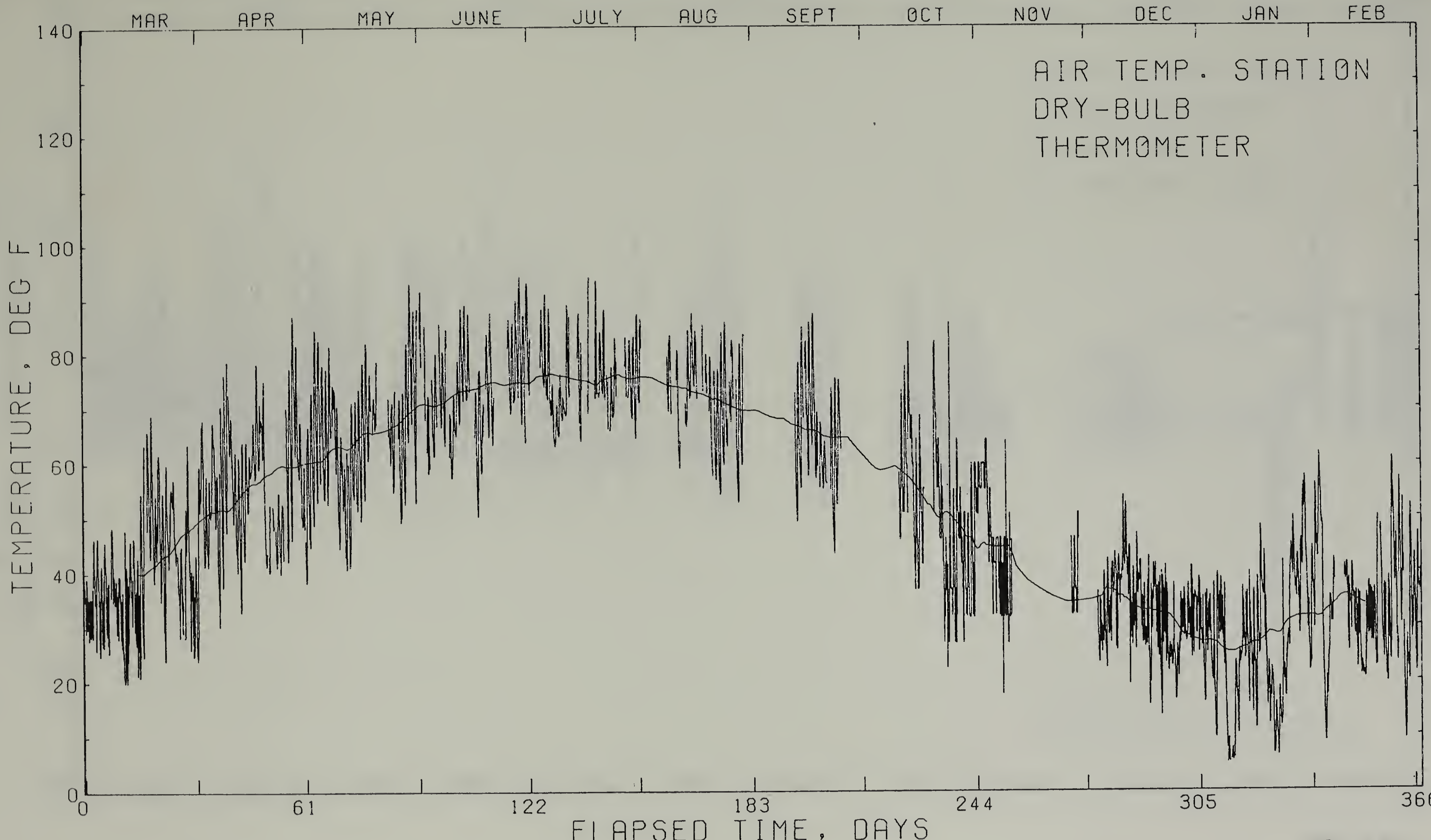

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
AIR TEMP. STATION
DRY-BULB
THERMOMETER
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-67

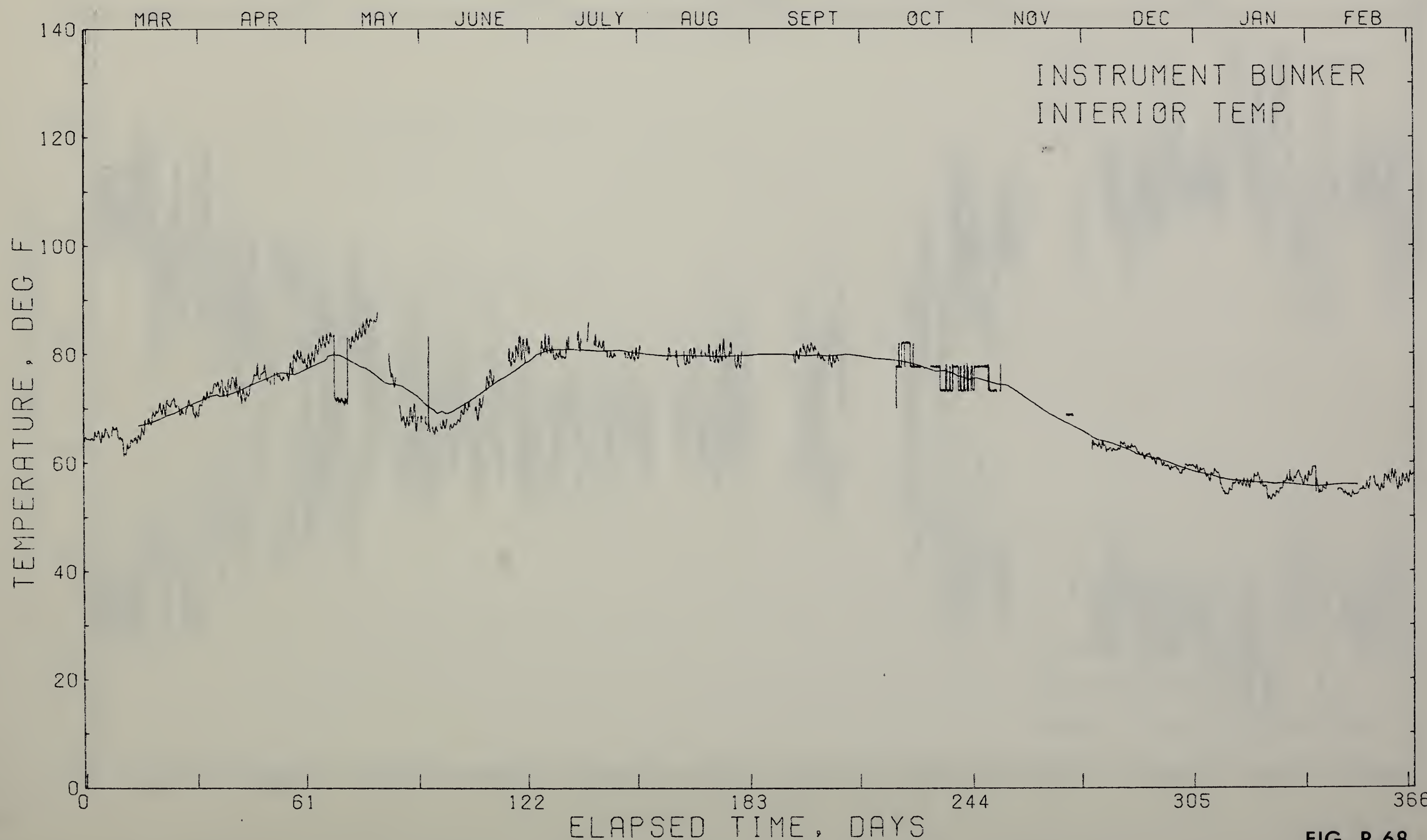

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
INSTRUMENT BUNKER
INTERIOR TEMP
TEMPERATURE, DEG F
140
120
100
80
60
40
20
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-68

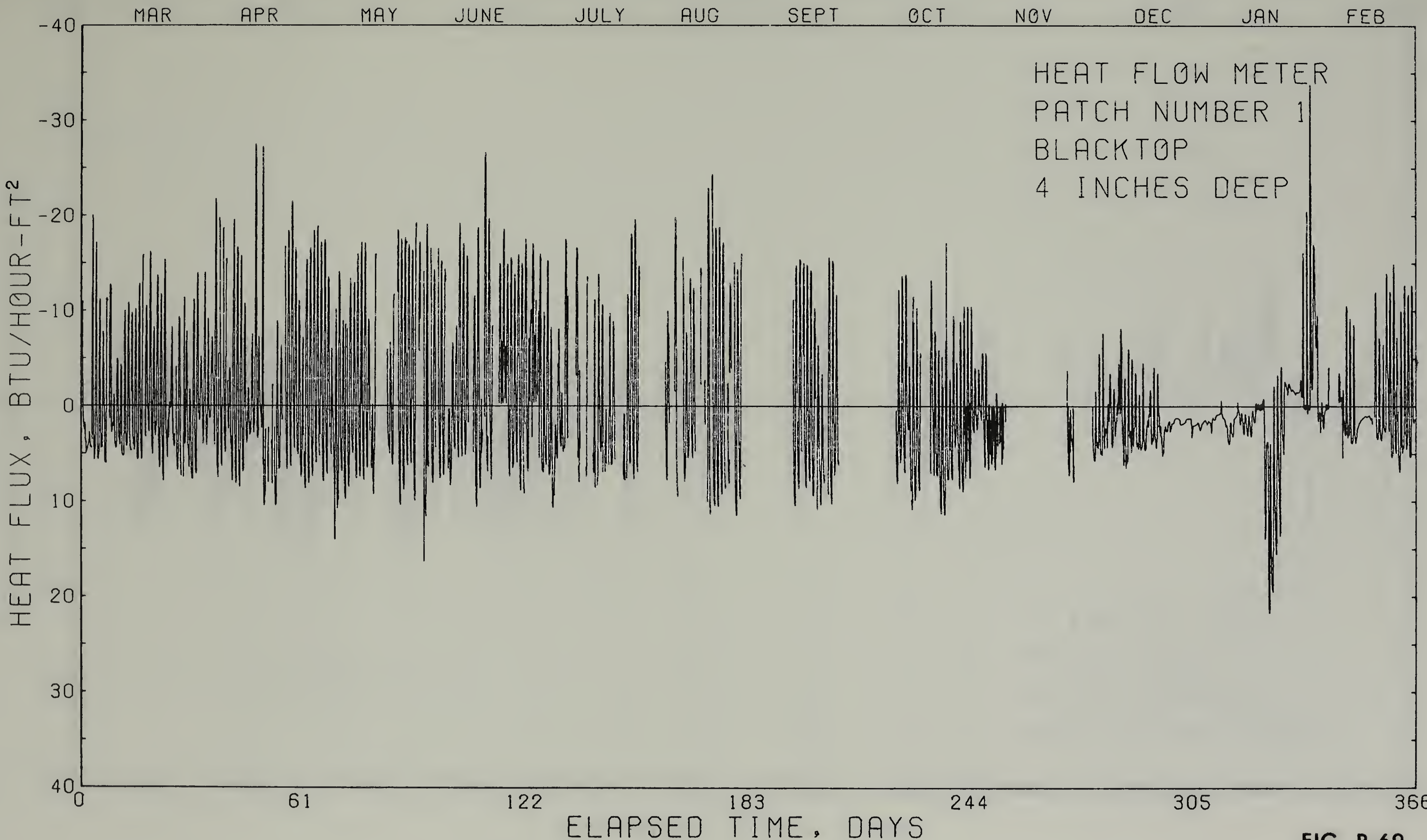
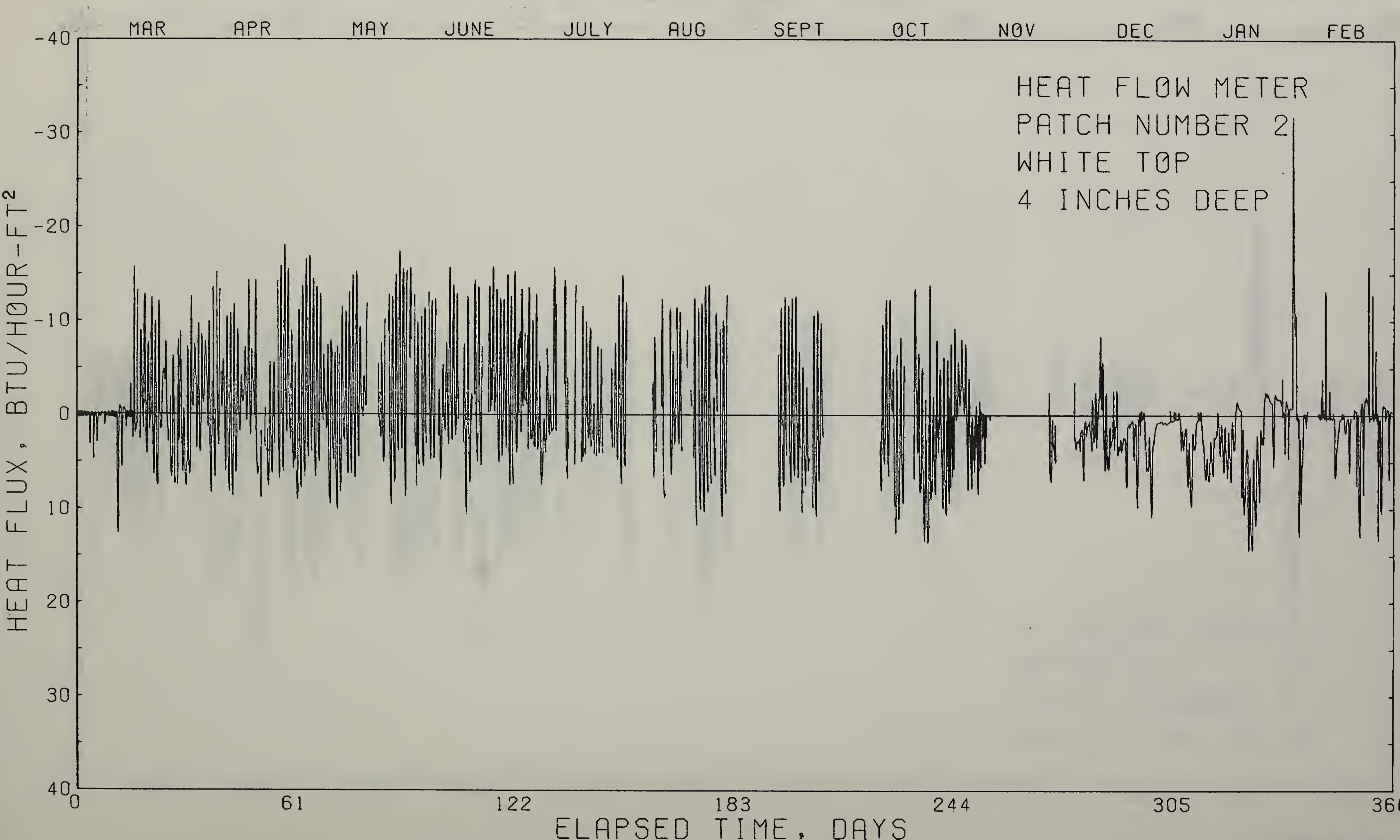
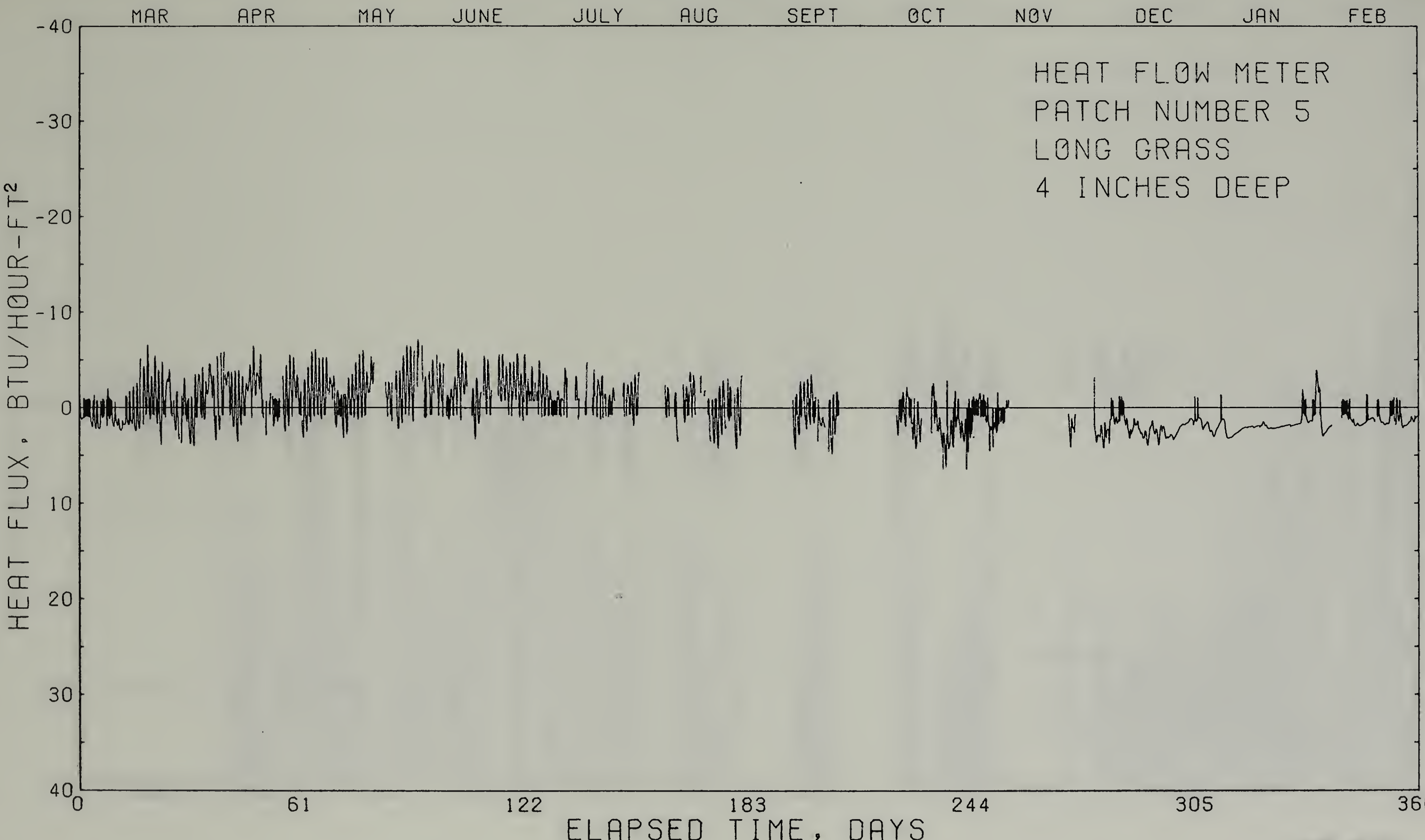

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
HEAT FLOW METER
PATCH NUMBER 1
BLACKTOP
4 INCHES DEEP
-40
-30
-20
-10
0
10
20
30
40
HEAT FLUX, BTU/HOUR-FT²
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-69



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
HEAT FLOW METER
PATCH NUMBER 2
WHITE TOP
4 INCHES DEEP
HEAT FLUX, BTU/HOUR-FT²
-40
-30
-20
-10
0
10
20
30
40
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-70



MAR
APR
MAY
JUNE
JULY
AUG
SEPT
ØCT
NØV
DEC
JAN
FEB
HEAT FLØW METER
PATCH NUMBER 5
LØNG GRASS
4 INCHES DEEP
-40
-30
-20
-10
0
10
20
30
40
HEAT FLUX, BTU/HØUR-FT²
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-71

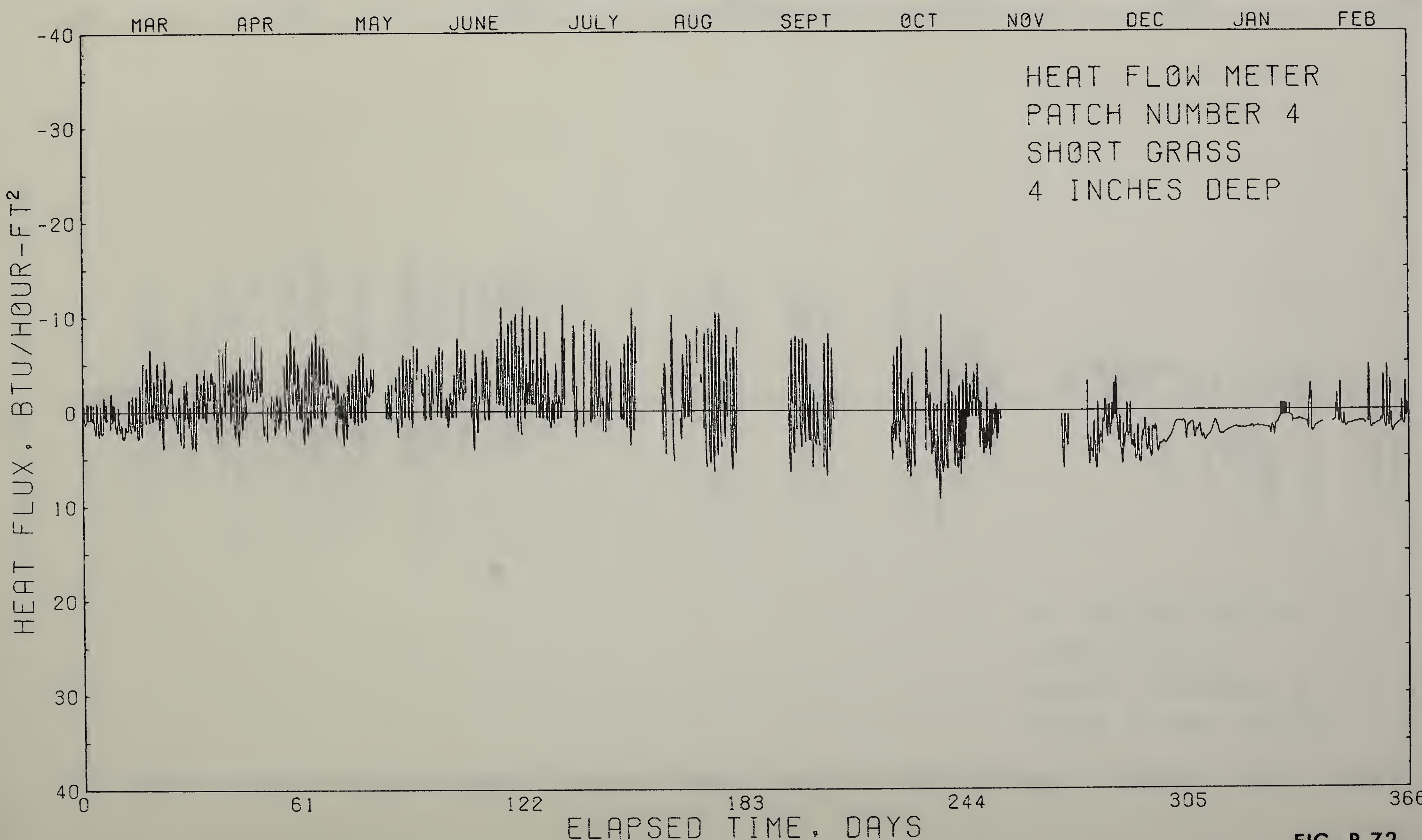

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
HEAT FLOW METER
PATCH NUMBER 4
SHORT GRASS
4 INCHES DEEP
-40
-30
-20
-10
0
10
20
30
40
HEAT FLUX, BTU/HOUR-FT²
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-72

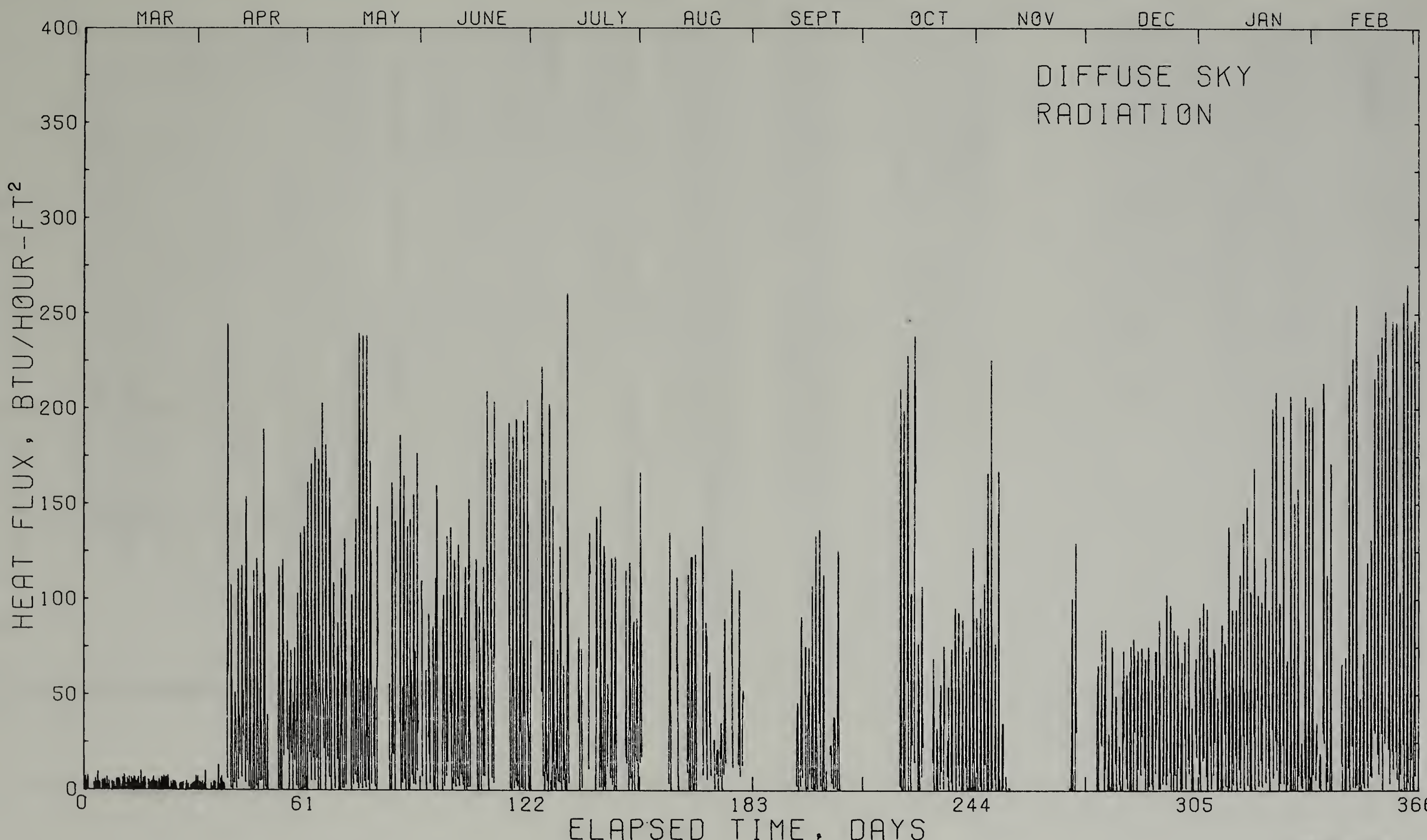

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
DIFFUSE SKY
RADIATION
HEAT FLUX, BTU/HOUR-FT²
400
350
300
250
200
150
100
50
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-73

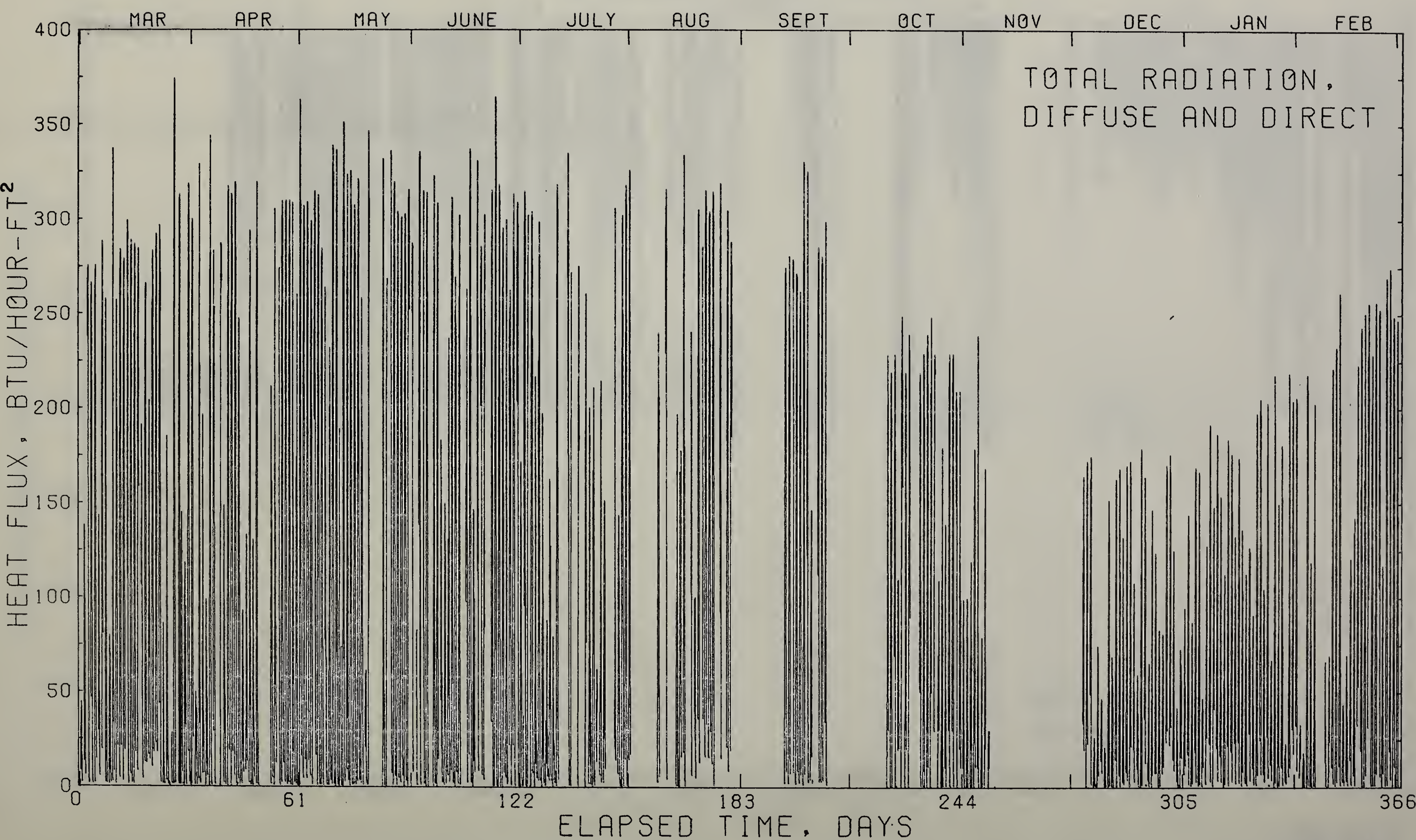

MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
TOTAL RADIATION,
DIFFUSE AND DIRECT
HEAT FLUX, BTU/HOUR-FT²
400
350
300
250
200
150
100
50
0
0
61
122
183
244
305
366
ELAPSED TIME, DAYS

FIG. P-74

DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS